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PROCEEDINGS OF THE SEVENTEENTH COTTONSEED PROCESSING CLINIC

Held at New Orleans, Louisiana
February 12 and 13, 1968

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

FOREWORD

The Cottonseed Processing Clinic is sponsored annually by the Southern Utilization Research and Development Division in cooperation with the Mississippi Valley Oilseed Processors Association, Inc., to acquaint representatives of the cottonseed industry with current developments in utilization research and to provide an exchange of information that will benefit future research.

These proceedings report the statements presented by the various speakers during the 1968 Clinic and give an account of the discussions during the three sessions.

C. H. Fisher, Director
Southern Utilization Research
and Development Division

DEDICATION

This Conferenee is dedicated to Edward A. Gastrock in recognition of his continued service throughout the years in the planning of the Clinic meetings and his contributions to the cottonseed industry.

GENERAL CHAIRMAN
R. C. Woodruff

CONFERENCE COORDINATOR
Shirley T. Saucier

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WELCOME

by
C. H. Fisher, Director
Southern Utilization Research and Development Division

I am happy to again have the privilege of welcoming you, old friends and new, to our Seventeenth Cottonseed Processing Clinic.

We in the Southern Division continue to be grateful for the privilege of sponsoring these clinics in cooperation with the Mississippi Valley Oilseed Processors' Association. We appreciate the opportunity of working with you for the benefit of agriculture and those who process and consume agricultural products.

During the past year, our research, conducted in cooperation with industrial associations and firms, has continued to be profitable. Some of our research findings have been adopted by other organizations and used for practical purposes, and some of our developments that were commercialized several years ago are being used more extensively.

We have had considerable success in processing both glandless and glanded cottonseed. There is great interest in the liquid cyclone process for manufacturing high-quality cottonseed flour from glanded seed for human use.

The national campaign for fire safety and the passage of the new flammability act have thrown the spotlight on Southern Division research in this area. Some of the flame-retardant treatments most extensively used for fabrics are based upon products of Southern Division Research, particularly THPC and APO-THPC. During the year we announced two new flame-resistant treatments: THPOH, a durable flame-retardant treatment suitable for lightweight apparel-type fabrics; and a flame-retardant treatment for Cotton Flote that makes this improved cotton batting even better for use in automobile interiors, bedding, and upholstered furniture. Mattresses made from flame-resistant Cotton Flote went on the market this year.

Equipment for the production of orange crystals, based upon the foam-mat process developed by the Western and Southern Divisions, has been installed in a Florida plant.

A new carbamate finish for durable-press cotton fabric was announced this year. In addition, the Polyset process is under advanced evaluation and nearing commercial adoption, as are some of the polymer treatments for durable press. Men's all-cotton, durable-press seersucker suits are scheduled for the market this summer, and production of similar seersucker for women's and children's apparel is planned later in the year.

Progress in our research was reported in 247 technical papers and 158 presentations to scientific and industrial groups, and in 39 patents.

I mention now what I consider to be one of the most important aspects of this Conference, namely, the dedication of this Seventeenth Cottonseed Processing Clinic to Mr. E. A. (Ed) Gastrock. I do not know of anyone who has worked longer, better, and in a more dedicated fashion for the

oilseed industry than Ed. His contributions have been great, his friends are numerous, and he is largely responsible for new developments that will improve the wellbeing of mankind all over the world. It is indeed highly appropriate to dedicate this Conference to Ed.

A great deal of planning and hard work is required to arrange the Cottonseed Processing Clinics. I wish to thank everyone contributing to the success of this Conference. In particular, I wish to thank the officers of the Mississippi Valley Oilseed Processors' Association, our General Chairman, Session Chairmen, the speakers, our visitors, and the staff of the Southern Utilization Research and Development Division for the arrangements that have made this Clinic possible.

OPENING REMARKS

by
J. H. Payne, President
Mississippi Valley Oilseed Processors' Association, Inc.

As representative of the Mississippi Valley Oilseed Processors' Association, it is with genuine pleasure that I express apprcciation once again for having the privilege of working with the Southern Utilization Research and Development Division at this the 17th Clinic.

It has been called to my attention that one hour has been allotted to me for my opening remarks. Rest assured, my good friends, that you are not going to be subjected to such punishment.

I cannot, however, let the opportunity pass without reflecting on the past Clinics and the tremendous amount of work done by you and your associates for the benefit not only of our industry but to all mankind.

Our industry has reached such a low ebb that there seems but one way to go. I honestly believe that we have hit bottom. I listened to a speaker once who made a point that I shall never forget. "When you are confronted with a serious problem and every aspect looms like a dark cloud, it is time to sit down and analyze this problem to see that is the very worst that can happen. If you will accept this formula, it then becomes forward progress as you save anything from that point forward." This might seem a little drastic to some of you, but, gentlemen, we do have some hope for the future.

We can look forward to a larger cotton crop next year which will permit larger crushes for all of us. It behooves each of us to take every advantage to reduce costs and to improve the efficiency of our operation. These Clinics have, over the years, pointed out many ways to help us accomplish these ends. A study of past Clinic brochures will be most helpful if you will only take the time and effort necessary to absorb the knowledge therein.

We all realize that a great amount of planning has gone into the program that is about to begin. As spokesman for our Association, I express to Dr. Fisher and all of his staff, our general chairman, Ralph Woodruff and his committee, and our

esteemed association secretary, Tom Allen, our deep and sincere appreciation for your splendid efforts in our behalf.

GOVERNMENT PROGRAMS FOR DEVELOPING NEW PROTEIN SOURCES FROM OILSEEDS

by
M. J. Foreman
Office of War on Hunger
Agency for International Development
Department of State
Washington, D. C.

(No copy of this paper is available for publication.)

SESSION I: W. Smith, The Southern Cotton Oil Co., Inc., Chairman

TRENDS IN THE UTILIZATION OF COTTONSEED OIL

by
H. R. Linstrom
Economic Research Service

I must begin by telling you that I am an economist—an agricultural economist. Further, I am an economist who, until very recently, specialized in marketing research and market development for new or improved farm products. I don't at all consider myself an expert in the area of oilseed products.

The preparation of my presentation today was most interesting and educational for me. Of course, I still do not feel that I am an authority on oilseeds and oilseed products. I do, however, feel that I can give you some insight into trends in the use of cottonseed oil, and, perhaps more important than any past or current trends, I would like to take a brief look into some of the future possibilities for your industry.

As I proceed, you will find that at times it was impossible to stick to the subject of cottonseed oil—it was difficult to separate the several joint products turned out by cottonseed crushing mills. Also, I have omitted the nonfood uses for cottonseed oil because only a small percent of the annual cottonseed oil production is used in making nonfood products.

There is seldom justification for anyone other than an historian to dwell on the past. I do not plan to dwell long on it today. You have all lived your industry's past—it is your past. You know that cotton acreage has dropped some 70 percent since 1951 and that the supply of cottonseed has shared in this decline, though not to the same degree as the acreage drop because of increased yields per

acre. 1/ You are aware of the excess capacity of the cottonseed crushing industry in recent years and you have undoubtedly seen some mills remain idle for a season or even go out of business. The search continues for other oilseeds that are adaptable to cotton-growing areas. 2/ We cannot drop the competitive oilseeds with just that brief mention. I am sure that you are aware, perhaps painfully aware, of the growth of the domestic soybean industry and the competition it has come to mean to markets which traditionally belonged to cottonseed oil. The capacity of the U. S. soybean processing industry has increased by nearly 250 percent in the past 15 years. 3/ During this same period, the efficiency and capacity per plant increased markedly as evidenced by a sizable decrease in the number of soybean processing mills between 1952 and 1967. Soybeans are not the only competition. Safflower oil also competed directly with cottonseed oil in salad and cooking oils. Domestic demand for safflower oil has increased in recent years because of its use in new products such as the soft "tub" margarines now available in our supermarkets. Even sunflowers have gained as an oilseed crop in the United States. In the past, sunflowers have been grown primarily for the whole seed trade. Seed varieties were uneconomic mainly because of their low oil content (about 28 percent). Recently, however, Russian seed varieties of sunflowers with an oil content of 40 to 44 percent have become available and this has renewed interest in producing sunflowers as an oilseed crop. In fact, the 1967 acreage planted to sunflowers in the Red River Valley of Minnesota and North Dakota was about three times that of a year earlier and about half that acreage is of oilseed varieties. We even hear that some 10,000 acres of sunflowers will be grown in Alabama during 1968. This is not the end of the sunflower threat either. Russian agricultural authorities predict varieties yielding up to 60 percent oil within a few years. 1/

A favorable factor for many companies in the cottonseed crushing industry has been their ability to change raw material sources from cottonseed to other oilseeds. The case of changing from crushing one oilseed to another depends on the oilseed involved and the extraction method with which the plant is equipped. The cottonseed crushing industry in the South has been fortunate because, while supplies of cottonseed for crushing were declining, soybean production in the South was rising rapidly. Had it not been for this, the cottonseed industry in the South would have experienced much more difficulty in recent years. In the West, oil mills have been turning more and more to safflower as a source of raw material.

Competition offered by other domestic oilseeds need pose no problem to a product which is low priced relative to its competitors. Unfortunately, cottonseed oil is not in this favorable position. In recent years, when cottonseed oil was in short supply, the price differential between cottonseed oil and soybean oil was 3 cents

1/ Fats and Oils Situation. U.S. Dept. Agr., Econ. Res. Serv., FOS-239. September 1967.

2/ Fats and Oils Situation. U.S. Dept. Agr., Econ. Res. Serv., FOS-234. August 1966.

3/ Fats and Oils Situation. U.S. Dept. Agr., Econ. Res. Serv., FOS-240. November 1967.

per pound. At the end of 1967, cottonseed oil was still selling at about 2 to 2-1/2 cents per pound over soybean oil. 3/ Even against an oil such as safflower, where cottonseed oil is in a favorable position priecwise, we find that safflower oil has certain desirable characteristics which add to its value and for which the manufacturer and the consumer are willing to pay a premium. It is a highly unsaturated edible oil made to order for the health-conscious purchaser of soft margarines.

If I seem to be dwelling on the supply and price of oilseeds, it is for a purpose. Utilization of cottonseed oil cannot be diseussed without developing some perspective as to how cottonseed oil and its supply and price situation compares with its competition.

Now, in the framework of this brief supply-price background, let's look at some of the specific end uses for cottonseed oil as well as for its competitors. In the manufacture of shortening, there has been a pronounced shift in the industry's raw material source since the late thirties. At that time, cottonseed oil accounted for 64 percent of the total fats and oils used in shortening. By 1965, the proportion had declined to 14 percent. Soybean oil, which accounted for only 15 percent of the oils used in shortening in the late thirties, held 52 percent of that market by 1965. A similar shift occurred in the margarine industry. In the late thirties, less than 30 percent of the oils used in margarine was derived from soybeans. By the late fifties, soybean oil accounted for about 85 percent and then gradually declined to 72 percent in 1965. This increased use of soybean oil in the manufacture of margarine was primarily at the expense of cottonseed oil. Twenty-five years ago, about half the oil used in margarine was cottonseed oil. By 1965, cottonseed oil accounted for less than 10 percent of this market. In addition to this pronouneed shift from cottonseed oil to soybean oil, there has been a significant inerease in the use of other fats and oils since the late fifties. In 1958, other fats and oils aeeounted for only 4 percent of the total used in margarine. By 1965, they accounted for 27 percent. 4/

Fortunately, the quantity of cottonseed oil used in the produetion of other food products such as mayonnaise, salad dressing, and cooking oils has been increasing over the past 15 years. In 1950, these food products accounted for about 30 percent of the domestic consumption, compared with 60 percent in 1965. 4/

Turning for a moment to some more recent figures, we find that consumption of cottonseed oil in all its edible uses declined by over 200 million pounds between 1965 and 1966. This breaks down into a decline from 915 million pounds to 746 million pounds in salad and cooking oils, from 403 to 370 million pounds used in baking and frying fats, and from 114 to 107 million pounds in margarine. Other edible products accounted for about 25 million pounds of cottonseed oil in both 1965 and 1966. During the same period, the use of soybean oil in edible products was up over 750 million pounds. This gain was evident in all the edible-use categories just mentioned for cottonseed oil—from salad oils to margarines. The use of both peanut oil and

4/ Agricultural Markets in Change. U.S. Dept. Agr., Econ. Res. Serv., Agr. Econ. Rpt. 95, July 1966.

safflower oil in edible products was up sharply between 1965 and 1966. There is no reason to think that any of these trends will be reversed when the 1967 figures are available. Indeed, changing food habits in our nation and the continuing publicity given to polyunsaturated fatty acids and their relationship to heart disease are among the factors which are likely to accelerate certain of these trends.

Coming up to the present time, your industry's dependence on the production of cotton lint was forcefully brought home during last year's short crop. Since lower priced soybean oil has displaced considerable amounts of domestic cottonseed oil over recent years and, thus, made larger quantities of cottonseed oil available for export, let's look at what a short cotton crop does to exports of cottonseed oil and meal. Cottonseed oil exports declined almost 72 percent. From 273 million pounds shipped during the October 1965 to September 1966 period, exports dropped to about 78 million pounds in 1967. This was due in large part to diminished stocks and reduced plantings in the United States with resultant sharply higher prices. Also, cottonseed meal exports declined by 93 percent during the period of October 1966 to September 1967 compared to 1965-66. As in the case of cottonseed oil, the decline primarily reflected sharply reduced U.S. supplies and higher prices. 5/

Speaking of meal, we can identify another trend here. The shift of interest from the use of cottonseed meal as an animal feed to its use as a source of protein for human nutrition has focused attention on the development of improved methods for production of a high-quality flour. There can be little doubt that cotton has the dual potential for helping to feed as well as to clothe our exploding world population. With predictions calling for that population to top 7 billion in about 30 years, every possible source of protein for human nutrition must be investigated. Three promising methods for producing high quality flour are now under investigation at SURDD. These include: Air classification, aqueous acetone extraction, and hexane extraction by an adaptation of the liquid cyclone process. You will be hearing more about these investigations later in the program.

Your "finished" product, in all its forms, enters a highly competitive market when it leaves your hands. That very competition is what makes it so difficult to regain those portions of a market either at home or abroad, which might have shifted to a substitute oil or meal. These are the kind of shifts which are taking place. The longer you are faced with a short supply and rising prices the more risk you run of losing markets. Here, again, you need look no farther than the lint cotton trade to see the burden they bear as a result of last year's short supply of spinnable cotton and the very real danger of cotton's being displaced by man-made fibers in various segments of the textile industry. Your cousins in the lint trade will tell you how difficult it is to recapture a lost market.

It is obvious that there are, and will continue to be, problems for the cottonseed industry. But, also, there are potentials for the industry and ways to guard against some of the problems which arise

5/ Fats, Oils, and Oilseeds. U.S. Dept. Agr., Foreign Agr. Serv. Cir., December 1967.

from dealing with this byproduct of the cotton industry. Cottonseed is just that, the same as lard is a byproduct of pork production. We might look for a moment at just two possibilities—first, some degree of diversification and, second, the promotion of cottonseed oil. Some of you are already involved in the former.

Those who engage in activities other than cottonseed processing—such as crushing other oilseeds, mixing feeds, and distributing seed and other farm supplies—are already engaged in a diversified business operation. By not putting all your resources into a single process, you are probably able to operate more efficiently than some of your "single business" neighbors. For example, a drop in the supply of cottonseed for crushing need not be a disaster if you are located in an area where some other oilseed is available (and most of you are) which can be processed with the same equipment or with minor modification of existing equipment.

The feasibility of an advertising and promotion campaign for cottonseed oil would largely depend on the availability of money and, since none of us ever have enough of that, let me offer this promotion idea for your future consideration. The building of a quality image for a product is certainly possible nowadays. To make cottonseed the vegetable oil for the household and institutional consumer to buy for salad and cooking purposes would not be impossible. The problem, of course, would be the fluctuating supply of cottonseed oil from one year to the next. Even this could be tolerated. We have all read or heard those advertising appeals which ask one to be patient, "if your grocer is temporarily out of stock." A promotional idea such as this for cottonseed oil might seem quite far out at the moment. Perhaps it is as far out as a similar idea when it was recommended to the cottonseed oil industry in 1962. A report at that time from the National Cottonseed Products Association recommended promoting cottonseed oil and noted that, "The superior quality characteristics of cottonseed oil offer the most logical approach to successful promotion.[6/]" It is a possibility worth considering.

Let me close by considering for a moment what it is likely to mean in the future to be dependent on the cotton lint trade. The National Advisory Commission on Food and Fiber recently referred to the role of cotton growing in the United States as a, "declining, Federally subsidized industry with static or shrinking markets both at home and abroad." The Commission further stated that, "Broadening markets for U.S. cotton is the only way to make cotton growing a viable industry and efforts in this direction are being increasingly emphasized for solving the U.S. cotton surplus problem, and increasing farmers' incomes. The Cotton Research and Promotion Act of 1966, under which farmers may contribute to a cotton research and promotion fund in accordance with their production, is a step in this direction."[7/] It is a step in the right direction, but, as long as cotton growing as a whole is in any kind of trouble,

6/ Peterson, L. J. A Market Study of the Demand for Cottonseed Oil. National Cottonseed Prod. Assoc., Inc. June 1962.

7/ Cotton and Other Fiber Problems and Policies in the United States. Natl. Advisory Comm. on Food and Fiber, v. 2. July 1967.

the cottonseed oil industry is in trouble. The 1968 cotton crop will undoubtedly be better than last year's but a good 1968 will not necessarily bring an end to year-to-year fluctuations in the supply and price of cotton lint and cottonseed. Promoting those quality characteristics of cottonseed oil should be looking like a good idea about a year or so from now.

REQUIREMENTS OF OILSEED MEALS AND FLOURS FOR FOOD USE

by
H. L. Wilcke, W. H. Martinez, and F. E. Calvert
Ralston Purina Company
(Presented by H. L. Wilcke)

When we think of oilseed meals, we are usually considering something that is intended for animal feed use. When we think of flour we are thinking of something that is to be used for humans. Flour is usually a finely ground, screened, graded product obtained from selected, sound, clean dehulled oilseeds from which most of the oil has been expelled or extracted. The flour is usually a product which has approximately 50 percent protein, about 1-1/2 percent fat, and 3 percent fiber at a 6 percent moisture level. The meal will have approximately the same chemical composition, (we are not considering the high fiber meals as being an important factor in the food picture) so for this purpose we may consider these as identical products differing only in particle size—the meal is coarser and more gritty to the touch. In addition, we do have the full fat soy flour available on the market which has not had the oil extracted.

The subject under discussion today is defined as "Oilseed Meals and Flours for Food Use," but there have been very intriguing developments in the production of concentrates and isolates which show real promise in the food field. The flakes and flours are used as raw materials in the production of these products.

While we have no definitions for oilseed concentrates in general, a soy concentrate has been defined as, "The product prepared from high quality, sound, clean, dehulled soybeans by removing most of the oil and water soluble nonprotein constituents and shall contain not less that 70 percent protein (N x 6.25) on a moisture-free basis." The isolates, as the name implies, are protein fractions isolated from the defatted flakes or flour. The protein content of the isolate, when calculated on a Nitrogen x 6.25 basis, varies from approximately 92 to 95 percent, or on a moisture-free basis from approximately 97 to 100 percent protein equivalent. The fiber is quite low and the ash is also low. Thus, the protein is provided in much more concentrated form, and consequently less of these products are added than when the flour is used directly.

The terms "oilseed meals and flours" cover a broad spectrum of possibilities, but for the purpose of this discussion, we will consider primarily the soybean and cottonseed products. Actually, soybean products are being used much more extensively than those from any other oilseed, but since different seed proteins

show different properties, we must eventually study all commercially available oilseeds to define their characteristies and determine their possible uses. As one example, a protein isolate from the soybean is soluble at pH 6.5 to 7.5, whereas an isolate from cottonseed is soluble in an acid range of approximately pH 4.0. This difference alone would indicate differences in usage for the two products, the latter being adaptable to use in low pH drink, whereas the former would be better adapted to general food use. Exploratory work with other oilseeds such as sunflower, peanuts, and crambe should be encouraged.

Since the ultimate use of these products will determine the requirements, it seems reasonable to start with the intended uses and then work back from that. The probable use of oilseed flours and meals and their derived products may be divided into two broad categories:

1. They may be used as supplements to conventional type food products in powder, extruded, or spun form.
2. They may be used as starting material for the production of new food products.

When used in these two catcgories, the oilseed meals, concentrates, or isolates serve four classes of purpose:

1. Functional characteristics—To act as a binder and thus to retain moisture and flavor. The protein fraction acts as an emulsifier, and when used in bread produces a finer, more tender texture, a more moist loaf with longer keeping qualities. In doughnuts, the use of these products will result in less fat penetration and help to prevent the objectionable sogginess. Soy concentrates are added to comminuted meat products for the purpose of emulsifying fat and as a binder, and it serves to prevent some of the eooking loss in this type of meat product, preserving the juices and therefore the flavor, more fully. They are also used in spreads, noodle products, baby foods, etc. One of the advantages of the use of this type product is that the properties of moisture absorption and binding are not reduced during heating. The much longer shelf life of this type of product makes it useful in certain areas where meat, as such, cannot be used.
2. Texture—To provide texture. These products are extruded or spun. The textured products have been provided for use in granule, flaked, diced, and shredded forms. They have been suggested for use in making up new types of products which may simulate or imitate products with which we are all familiar. The extruded and spun forms will impart a "chewy" consisteney where this is desired. The protein in the powdered forms may also provide texture in the final food produet. When added to such comminuted meats as frankfurters, proteins will impart a firmness of consistency which seems to be desired by customers. It will be noted that in all of these uses, the primary purpose of the oilseed protein product is that of improvement of texture and as a substitute for more expensive items.
3. Color—To modify the color of products. Cottonseed flours have been used quite extensively for the purpose of improving eolor by means of color additions, such as in doughnuts and other baked products. Paradoxically, raw soy flours have been used

to bleach or improve whiteness through enzymatic action on wheat flours. There is a product on the market which is used for this purpose. Color may be a very important characteristic of the end product depending upon the ultimate use. For some uses we want color and for others we want lack of color, but certainly we do not want off color in any of the product.

4. Nutrition—To increase the protein content. The usual level for this purpose is in the order of from 3 to 5 percent, but there is no reason why somewhat higher percentages cannot be used, if needed, to bring the protein to the desired level. This is frequently desirable in bread and other baked goods and is employed in macaroni and spaghetti as well as in the baby foods.

The oilseed flours may be used to improve the quality of the protein which already exists in a product; for example, to provide the components for baby foods or to provide protein in drinks where protein fortification is desired. These are also used where allergies to other types of protein may exist, and they are used as an economical source of protein. For this purpose the flour must be extremely finely ground and not gritty to the touch.

All of this, of course, brings up the question in the minds of many people why we should consider this relatively new type of protein food product when we have such a plentiful supply of protein in the United States. From the nutritional viewpoint, we have in the oilseed protein products, excellent sources of protein. On an "as is" basis, the soy protein is a very good protein. Supplemented with methionine, it is an excellent protein. The same may be said of glandless cottonseed protein except that in this case the first limiting amino acid is lysine. However, we in the United States very seldom, if ever, buy protein. In fact, if the average housewife were asked to define protein, she would probably respond in terms of meat, milk, or eggs. Therefore, if these oilseed protein products are to take their place in the food industry, it must be on the basis of unique characteristics. They must supply something that is not generally available from other sources, or they must supply it better. Thus they may be used as binders, emulsifiers, as means of providing a vehicle which will carry desirable flavors or texture while in themselves being essentially neutral in flavor, they may reduce cost, or provide products that, in their own right, are preferred by the consuming public.

Obviously, then, we are discussing food products and we must gear our thinking to the production of food products under food processing conditions. The Federal Food, Drug, and Cosmetic Act provides that a food shall be deemed to be adulterated "if it has been prepared, packed, or held under unsanitary condition." This means that we must not only provide an end product that meets all of the specifications for food use, but it must have met those conditions during the entire period of processing.

This entire operation, then, must start with the selection of the seed to be used in the preparation of the flours or meals. These are some of the criteria for grading the seeds that are to be used:

1. The seed must be graded and selected. Not all seeds will qualify.
2. Select sound, mature, clean, and whole-

some seeds with low total bacterial count and reasonably free of pathogens. To qualify, it must be free from mold or mold toxins, it must be free of toxic weed seeds, such as crotalaria, belladonna, etc. It must be free of rodent or bird excreta and other contaminants such as dirt, sand, etc. It must be free of discoloration, frost damage, and bin burning.

The necessity for freedom from molds, mold toxins, and weed seeds is obvious and needs no further explanation; nor does the necessity for freedom of filth. Insect puncture may indicate the presence of insect eggs, and, of course, it may alter the composition of the resulting materials. Frost damage may alter both chemical composition and functional characteristics, the degree of damage depending upon the state of maturity of the seed when the frost occurred. Bin burning may not only affect the color and flavor of the product but it may also indicate heat denaturation of the protein depending upon the severity, and heating may damage the quality of the oil. Weathering in outdoor piles may also result in deterioration.

Following selection of the seed, the storage is very important. The seed must be protected from insect and rodent damage and from excessive moisture, and cleanliness must be maintained. Another consideration in the selection of seeds for this purpose is the chemical composition of the seeds themselves. When we are producing this type of product, we are meeting a specification for amount of protein and protein qualities (both functional and nutritional), fat, and fiber, as well as for cleanliness and appearance.

The composition of the seed will influence yields and costs very materially. In the soybean, we are dealing with a seed that will yield approximately 40 percent protein (on an N x 6.25 basis) and 20 percent oil. The hull also yields some nitrogen. In the cottonseed, we are dealing with a seed that will analyze approximately 19-1/2 percent protein and also 19-1/2 percent oil, but with a much higher fiber content. It should also be remembered that the seed coating of the cottonseed carries virtually no nitrogen. Therefore, if we are to produce a 50 percent flour, we must start with a soybean that has a minimum of 36 percent protein. Unfortunately, protein levels in soybeans may be much lower ($\pm$ 32 percent). We must start not only with a cottonseed that meets the protein level, but also with a hull that must be removed as completely as possible. Further, dehulling must be as complete as possible to remove this probable source of bacterial and mold contamination, since most of this contamination comes from the hull rather than from the seed inside the seed coat. It must be emphasized that fiber must be very low in these products for human consumption and, indeed, is not acceptable at all in the concentrates and isolates.

These, then, are some of the reasons for insisting upon mature seed in the seed selection. These are also reasons why geneticists should consider the nitrogen content of their seed and put pressure on keeping the nitrogen content within at least these levels if the product is intended for human food use.

When soybean flours are to be used without further preparation, sufficient heat must be applied to inactivate or destroy the antinutritive factors, such as the anti-

trypsin factor, and to improve palatability and flavor, but heating must be stopped short of adverse effects upon nutritive value, dispersibility, etc. When further heat is to be applied before the product is consumed, less heating is necessary in processing. Since no such anti-nutritive factors have been identified in cottonseed flours, the heat is kept at a minimum consistent with adequate removal of the solvent. Coagulation or denaturation of the protein must be avoided. It is obvious, then, that as we approach this problem of producing flour, concentrates, or isolates for human consumption, we are dealing with a more complex chemical operation and we must exercise more control—more rigid control—in the application of heat, in the removal of solvents, and in other processes which will be discussed by Mrs. Martinez later today.

This brings us to the question of whether a plant that is presently built and operated to produce meal for animal feed use may be used to produce flakes or meals for human consumption. Obviously, most of our plants are not so equipped today. However, it seems equally obvious to me that with the present emphasis on Salmonella, Shigella, and other micro-organism contaminants, for both feed and food use, that the plant which is going to produce feed products in the future will have to be equipped to handle products on a much more sanitary basis than is usually done today. The fact that processing plants are producing oil which eventually is used for human consumption does not mean that a plant will necessarily meet food standards. First, a crude oil is produced which must be refined before it is ready for human consumption. Second, the oil is handled in a solvent system which is not conducive to the growth of bacteria.

We are not inferring by any means that our plants are not operated under sanitary conditions. We are simply pointing out that the usual processing methods were not developed to produce products free of micro-organisms.

If our regulatory authorities at some future date should decree that animal feed must be free of pathogenic organisms, our plants for the production of animal feeds and animal feed ingredients are going to have to be equipped to meet human food standards. If that time should arrive, the question of whether this type of food products could be produced in a plant which is also producing animal feed products would become academic. For the present, however, it is quite obvious that meal, flakes, and flours to be used for human consumption must be processed in plants which are equipped to meet human foods standards. This does create some problems because, as this type of product finds its way into human food channels, there is going to be a necessary period of growth when the volume of product produced will hardly pay for the investment in a plant. Until the volume of product reaches the point where plant operation is economical, the plant will have to be used as a combination food and feed producing facility. But the point we are making is simply that we will be selling some human food grade material for animal feed and not vice versa.

The oilseed protein products provide an excellent source of protein which can and will be very useful in preparing products for human consumption. These products will supplement our diet. The amounts that will be used will be determined by their properties and by their

cost. The versatility of the oilseed protein products permits the imagination to envision a large number of products that might be produced. Therefore, we may expect to see a greatly increased use of oilseed protein as supplements to our present human diet, as technology improves, as the economics of this type of product improves, and as we learn more about how to incorporate these foods into foods that are wanted by the consuming public. This is not going to come overnight. It is going to require skill to produce products that will find a volume place in our markets. It is going to take study and imagination to find the proper niche for these types of products in the American diet, and it's going to take a lot of good, hard work. The possibilities are great, the rewards are there—it is up to us to find the key to the proper use of these very fine food items.

SESSION II: G. H. Dunklin, Planters Cotton Oil Mill, Inc., Chairman

THE PRODUCTION, PROCESSING, AND POTENTIAL OF GLANDLESS COTTONSEED FLOUR FOR HUMAN NUTRITION

by
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When we attempt to deal with this subject, which, indeed, is entirely too broad for precise treatment, we must first recognize that there are many unknowns and that both conditions and approaches fluctuate rapidly. Conclusions which appear valid at one time may be supplanted soon thereafter with conflicting viewpoints. We have found this to be true in the glandless cottonseed program as it has evolved and certainly the condition is outstandingly typical of the movement toward use of vegetable protein concentrates in human foods. Yet, out of this maze of apparent confusion two factors stand out. First, glandless cottonseed work has made tremendous progress and is well on the way toward realization. Second, the use of vegetable proteins in human foods probably will be the most significant development in the food industry in the immediate years ahead.

A third conclusion appears to be entirely logical. The cottonseed industry, as a major producer of protein, simply cannot fail to make itself a part of the evolving use of vegetable proteins in human foods. The need to find such new market outlets is an extensive and vital subject within its own right and can only be given passing mention in this paper. However, we cannot fail to emphasize again, as we have in the past, that the traditional markets for cottonseed protein are going to be in severe difficulty because of the ever-increasing acceptance of nonprotein nitrogen in ruminant animal rations. We must also emphasize that today the cotton industry desperately needs every contribution which can be made to the net farm value of the crop. A significant contribution can be made by developing

commercial glandless cotton and by making full use of the potential value of cottonseed protein.

The paper preceding this one and the paper which follows are concerned more specifically with factors related to processing. Therefore, we shall devote much of our discussion to the status of the development of glandless cottonseed into commercial reality.

In a paper given at the 1967 Cottonseed Processing Clinic, we reviewed in some detail the history of glandless cotton and the subject has been treated fully by many authors prior to this time. Our purpose now will be to concentrate on the current status as it relates to commercial production. The prospects are highly encouraging, but reality prevents our specifying exact target dates which all of us need to guide our activities and planning.

Less than a year ago our Association added to its staff a plant breeding specialist, Dr. Robert Miravalle, for the primary purpose of reducing the time required to commercialize glandless cotton production. His activities have been highly beneficial to us and we hope and believe they have been helpful to cotton breeders. While we must recognize that many breeders have not met the time tables they had earlier set for themselves, we find that conditions observed by Dr. Miravalle justify an atmosphere of optimism and excitement.

When we reflect upon the magnitude of what we attempted to do—incorporate a major genctic change into commercial cottons without sacrificing yields or fiber quality—we must conclude that tremendous progress has been made. Research in breeding has been completed and it has been successful! Action now has moved to development with the full assurance that we know how to do the job and with good comprehension of the rewards which await the commercial production. The cotton breeder now has at his disposal the tools necessary to make the change. With rare exceptions, they possess and are using advanced germ plasm, breeding, and selection procedures. Thus, the success of our mutual venture is now in the hands of the commercial cotton breeders who develop the varieties growers plant. Your attention is especially called to our emphasis upon commercial cotton breeders. Those breeders at State and Federal institutions have contributed greatly to the development of highly advanced germ plasm. Unfortunately, they are generally not in position to carry through on the seed increase and merchandising phases which are vital to commercial planting.

Now, let us examine the attitudes, activities, and other factors which govern the performance of these commercial breeders in such a program.

They, like all of us, are profit motivated. They give major emphasis to developmental objectives which promise the most profit and that profit is largely determined by grower acceptance of their varieties. We can call plant breeding a science and be correct. Yet, a large portion of it becomes an art in practice. Each breeder has fixed in his mind certain plant characteristics and he insists that each of his releases conform to that type. Yield tests and mechanical measurements are tremendously important, but both selections and releases must almost universally pass the "eye balling" test. Thus, when a commercial plant breeder brings in germ plasm for a certain

character he may depend upon scientific measurement to make certain that it is in the material he releases, but you can be sure that those stocks are finally going to be made to conform to his idea of what a cotton plant should look like and how it should perform before he will ever place them in the varietal status for release. We might emphasize here that cotton breeders, as a whole, are tremendously influenced by the possibilities of use of cottonseed protein as a human food. This impression has probably been the greatest incentive they have had in their work with glandless cotton.

We believe there is every evidence that, as a whole, cotton breeders today are more interested than ever before in the release of glandless cotton. We cannot emphasize this point enough. As Dr. Miravalle has talked with these breeders and observed their glandless materials he has been surprised with the excellent quality of their glandless stocks. What is probably more important, the breeders are impressed with their own progress. He reports that the typical comment now is, "You simply must come out in the breeding nursery and see some of the good plants which are segregating out of my glandless stocks." What a contrast this is to the typical comment of a few years ago when so many breeders were saying, "My glandless stocks simply do not look like cotton." They then appeared to be somewhat defensive and perhaps a little ashamed of their materials.

Thus you can see that the attitude of most breeders is no longer one of debating the practicality of developing agronomic lines of glandless cotton. Their conclusion, like ours, is not "if" but "when" they will release glandless varieties.

You, like we, are interested in pinpointing that "when" date. We wish we could do so more precisely than there is justification for attempting at this time. However, let us get the picture in focus just as clearly as present indications will permit.

In 1968 the first glandless variety of cotton, released first in 1966, will be grown to some extent in the Texas South Plains area. We get the impression from the breeder that he recognizes that his variety has not been popular with cotton growers and probably the acreage will be less than in the two earlier years. The lack of success appears to have no relationship to the glandless character. It was released as a verticillium wilt tolerant cotton and it performed well in this regard. There are conflicting reports on its fiber characteristics under commercial production conditions. It has yielded well for some growers and has failed to yield well for others. Certainly, its fiber quality is not equal to what is needed although the breeder's own data show that it is better in this respect than his earlier variety. One principal deficiency appears to be its lack of stormproofness which is essential in that area. The breeder reports that he has been able to make improvements in the variety and hopes that these improvements will secure for it better acceptance in the future.

Another breeder in Texas has developed a glandless variety which appears to have acceptable characteristics and it is in the hands of a seedsman who will, in 1968, both increase and thoroughly test its capability. Both the breeder and the seedsman

are very excited over its potential and it is expected that it will be released on a wide scale in Texas, Oklahoma, and western Arkansas for 1969 planting. This breeder has other developing glandless stocks which he believes to be superior to the one he has released to the merchandising seedsman.

One of the major breeders has a high quality fiber glandless breeding stock which may be released for planting in 1970. The Arkansas Agricultural Experiment Station has two glandless stocks which are reported to be of varietal status but neither of these has been released for increase. A glandless line of stormproof cotton has been developed at the Lubbock Experiment Station. The breeder believes at this point that its fiber properties and other characteristics equal or closely approach those needed for varietal status. It will be increased and tested further in 1968 and may be released to seedsmen in 1969.

If all goes well with these developments, there might very well be a "snowballing" effect upon breeders and there could be widespread rush toward glandless variety release in the next few years. This appears entirely feasible because, as has been reported earlier, nearly all major breeders have excellent breeding stocks in their nurseries. Apparently they were not making idle promises earlier when they told us that they were doing enough work to make certain that they stayed in the mainstream of the movement and that that they were making certain that they would not be left behind.

If we are judging the status of these breeders accurately, the one thing we need most is a sufficiently large block of glandless cotton to establish the superior market value of the seed over glanded seed. We and the breeders are in complete agreement on the concept that total quality in fiber and seed must be the guiding principle in future cotton variety releases. Without fiber properties which will protect and regain cotton fiber markets cotton does not have much hope for the future. These higher quality fiber cottons are being released rapidly by cotton breeders. Most breeders are attempting to combine high-quality fiber and glandlessness in their breeding programs.

While the crushing industry was looking at the late 1960's as the changeover period to glandless cotton when we began our work and it now faces the fact that the significant portion of the changeover is to come in the 1970's, the farm production could well be ahead of developments for maximum use, especially as a human food. Now is the time for us to get our houses in order so that we will be prepared to achieve the maximum benefit from glandless seed. Strictly speaking, this means research and development.

Some oil millers may have been expeeting that the only thing needed was to have a supply of glandless seed. Let us be certain that we now correctly interpret what is known and make our plans accordingly.

Even though the feeding of monogastric animals is not included in the already too broad subject of this paper, we must deal with it briefly. It is true that glandless seed, as a raw material, will improve the quality of the products of almost any mill. The one exception is the mill which does severe heat damage during processing. However, let us make

certain that we understand that glandless seed respond most favorably to mild processing conditions. This should not be surprising to anyone. Any protein, be it soybean, fish, meat scraps, or other must have careful processing if it is to be most useful in monogastric animal feeds. Thus, any mill which attempts to process glandless cottonseed for monogastric animal feed is going to be disappointed in the acceptance of its protein for this use if it does not follow good quality control in processing. In summary, you will benefit from glandless seed but you are going to benefit in proportion to the care you use in processing.

When we move over into the field of processing for human food, we are going to have to learn much more and we are going to have to make some changes in several respects. First, we are going to have to understand that we are processing a human food product which must have certain precise characteristics whether they be in functional properties or nutritional values. Of these two, functional properties must necessarily come first. At the present time, the consumer gives little attention to nutritive value. He selects food on the basis of personal preference which involves such factors as physical form, taste, feel, color, etc. Furthermore, vegetable proteins which will be used in human foods will merely be ingredients in a formulation to which they contribute distinctive functional properties as well as a source of protein. With our present state of knowledge, vegetable proteins for use in human food may be broadly and somewhat arbitrarily classed as flours which contain 55 to 60 percent protein, concentrates which have not less than 70 percent protein, and the pure or near-pure protein which is isolated by placing the protein in solution which is separated from the insoluble fractions and then precipitated in an acid solution. Mrs. Martinez's paper gives specific information on conditions and procedures.

In our brief reference to processing we should consider what effect these more sophisticated procedures will have on the cottonseed industry. Several possibilities exist. Let me first state a strong personal conviction that this type of operation need not necessarily be removed from the province of the oil mill industry. Certainly it is true that changes in facilities are going to be made. Some mills may never be in the position to make the required changes. Others, possibly with a minimum of change in equipment, may place themselves in position to go a part of the way, such as producing undenatured protein residue. Still other mills may find it economically justifiable to go all the way in the installation of a protein isolation plant.

It has often been said that a feed plant cannot produce a human food-grade protein. This is true if taken literally. Yet, the one cotton oil mill which has long experience in producing a cottonseed flour has apparently encountered little difficulty. As Dr. Wilcke's paper has pointed out, sanitation and protection of quality are essential. This does not indicate, in my opinion, that a food plant, constructed as a distinct unit in conjunction with the oil mill, cannot operate within the requirements. In fact, the oil mill is already a food manufacturing plant according to the United States Food and Drug Administration designation. We might point out here

that oil mills would do well to accept this fact and become ready for ever-increasing close scrutiny of their sanitation controls. The oil mill which has a food manufacturing unit for the production of edible grade protein may find itself in a position of special advantage because that portion of the oil-free protein residue which cannot be made a part of the human food grade product may be diverted directly into the animal feed concentrate.

In conclusion, we believe we can look forward to the time in the not distant future when cottonseed value will be significantly increased by the production of glandless seed. The opportunities which then become available for advancement are most promising. However, it should be stressed that these are only opportunities. Realization of the potential depends, to a large degree, upon oil mill recognition of this opportunity and the willingness of the industry, individually and collectively, to work toward achievement through needed research and technological development.

SOME ASPECTS OF THE PREPARATION OF HIGH–PROTEIN COTTONSEED PRODUCTS

by
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It has long been recognized that there are three major areas which are important to the quality of a protein product from cottonseed. These are the quality and storage conditions of the seed, the conditions used in processing the seed, and the storage conditions of the final products. In his presentation, Dr. Wilcke emphasized the importance of seed quality and storage. At this point in time—with glandless seed so near and yet so far, with the invasion of urea in the ruminant market, and with the potential of new food markets on the horizon—it seems appropriate to examine the relationship between present processing techniques and the required properties of high-protein cottonseed products.

Two aims are fundamental to the preparation of high-protein products: (1) To provide maximum retention of the native solubility of the seed proteins and (2) to meet the end-use requirements for fiber and ash. The attainment of these aims is intimately tied to the manner in which the cottonseed is processed for the removal of the oil.

For the purposes of this discussion, I would like to divide cottonseed processing into the following areas:

Seed conditioning–dehulling
Meat-flake conditioning or cooking
Defatting
Desolventizing
Grinding

Within each of these areas there are two major variables which are important to the properties of the final product—moisture and heat. Heat, here, includes frictional energy.

Dr. Wilcke pointed out the importance of maximum removal of the hulls.

Preconditioning of the seed to a high moisture—13 to 14 percent— is a well known method for improving hull removal and reducing meal and hull fines. It must be recognized, however, that preconditioning of the seed and preconditioning of the meats are two different processes involving two diffcrent mechanisms. In seed conditioning, the uptake of moisture through the seed coat is the natural first step in the germination of the seed. The seed coat or hull acts as a metering device to allow the dehydrated cell walls and membranes to absorb water at a rate which is conducive to rehydration. This water becomes "bound" water—an intimate part of the chemical composition of the seed constituents. This natural rehydration does not occur in meat conditioning with the simple addition of water to dehulled cracked meats or flakes. This added moisture remains as "free" water, in high concentration, wherever it can most rapidly penetrate.

Recently, a processor has stated that within the normal range of moisture contents of cottonseed received at the mill, he could, by adding the same amount of moisture, produce the same effect on cooking, irrespective of the initial moisture content of the seed. He was in effect saying that the moisture content of the seed is not contributing to the final result obtained on cooking. It is the "free" water and heat which produce the desired effects on cooking.

What are the desired effects on cooking? Why are cottonseed cooked? Any list of objectives for cooking 1/ begins with the statement "to rupture the oil cells" but also includes the statement "to detoxify free gosspol by causing this material to diffuse from the resin glands." It is for the latter reason that "free" moisture is added. It was recognized, however, that in addition to rupturing the pigment glands and the membranes surrounding the lipid particles, certain constituents are being solubilized. In overcoming one problem, the processor created another. To prevent the coextraction of these solubilized constituents, the water must be removed by further addition of heat. The list of cooking objectives, therefore, also includes the statement "to coagulate or granulate the protein aleurone grains" and "to precipitate phosphatidic material."

Let us look at the raw material which is being processed. The cottonseed, when it takes up moisture during germination, unfolds to show two leafy appendages attached to a stem. These pseudoleaves are normally tightly folded even in high moisture seed and are the major storage sites for the lipid and protein of the seed—the food supply of the future plant. When we cut through these leaves, we see a series of cells differing in shape but similar in content, that is, they are all filled with bulbous shaped particles. By selective staining we can show that these bulbous shapes contain protein.

However, not until we go to the electronmicroscope level of magnification can we truly appreciate what a highly organized mechanism the seed actually is. Dr. Larry Yatsu has shown not only that the storage protein is packaged but also that the lipid and phosphorus of the seed are containerized in specific areas

1/ Fincher, H. D. In Processed Plant Protein Foodstuffs, A. M. Altschul, Ed., p. 67. Academic Press, New York. 1958.

as well. Packaged is an appropriate term. For both the lipid particle and the protein particle, which in turn contains the phosphorus particle, are each surrounded by a membrane. 2/

In addition to the various particles, the cell contains the normal complement of constituents needed to shift from the resting to the actively metabolizing state. This is the working machinery of the cell. The components of the cell can therefore be crudely divided into two categories: (1) The storage components which include the protein particles and the lipid particles, and (2) the working components which include the materials classified as the ground cytoplasm of the cell and its water dispersible constituents in which the protein and lipid particles are embedded. In addition to these cells with their particulates, there are of course, the pigment glands between the cells.

The end result of cooking this material is detoxification of the gossypol. But perhaps more important to this subject. the end result of cooking is also protein denaturation.

The major portion of this denaturation, however, affects only particular proteins, somewhere between 140 and 160° F. the "free" water-solubilized, "machinery" proteins of the cell are heat coagulated. In addition, the phospholipid-protein complexes, which are the residual membranes of the lipid particles, are coalesced around the protein particles. As a consequence the protein bodies are glued in position and surrounded by a more impenetrable barrier than the original membrane. The highly organized particulates of the cell become an agglomerated mass.

If pressing is used, the energy involved in pressing operations simply extends the events initiated in the cooking operation to the point that even the protein body proteins may be denatured.

Events similar to those that occur in cooking also take place in desolventization. Here the moisture or steam which is added displaces the solvent. Under these circumstances, the proteins are probably affected to an even greater extent because the lipid is no longer present to aid in the dissipation of the heat and the water-soluble proteins can be brought into intimate contact with those constituents involved in browning reactions.

Because of the marginal lysine content in cottonseed, it is also evident that any denaturation of the high-lysine, water-soluble proteins will mean a real decrease in nutritive value. A recent publication from our laboratory has shown that the free-steam autoclaving of a hexane-extracted, air-dried, glandless cottonseed meal for 20 minutes followed by 15 minutes of vacuum drying reduced the protein efficiency ratio by 37 percent. 3/ This procedure is a reasonable approximation of a desolventizing-toasting operation.

Each of these steps—cooking, de-

2/ Yatsu, L. Y. The Ultrastructure of Cotyledonary Tissue from Gossypium hirsutum L. Seeds. Jour. Cell Biol. 25: 193-199. 1965.

3/ Martinez, W. H., Berardi, L. C., Frampton, V. L., and others. Importance of Cellular Constituents to Cottonseed Meal Protein Quality. Jour. Agr. Food Chem. 15: 427-432. 1967.

fatting, and desolventizing, will obviously affect the properties of high-protein products. The extent to which the color, flavor, and dispersibility of a flour deviates from the white, bland, highly dispersible ideal of the food industry will be a summation of the intensity of the denaturation at each step of the operation.

The production of a protein concentrate by air classification is dependent upon the liberation of the intact protein bodies after rupture of the cell wall by grinding. The protein particles are then separated from the cell wall, the ground cytoplasm, and residual lipid membrane fragments on the basis of size, shape, and mobility in an airstream. Any flour in which the protein bodies are glued in coagulated protein and surrounded by precipitated residual membrane cannot be used for such a procedure. The large quantity of glandless meal recently produced is an excellent case in point. Grinding of this meal simply produced smaller particles of the coagulated mass and did not liberate the protein bodies from their cellular environment.

The type of grinding is important to the air classification. Selective grinding rather than complete grinding to a single particle size is needed to achieve the desired result. There are also three points in the preparation of a flour for air classification in which "bound" moisture could be important to yield and nitrogen content: The moisture in the meats prior to flaking, the moisture in the meal prior to grinding, and the moisture in the flour prior to air classification. This aspect of the air classification process is presently under investigation.

These same steps in processing will also affect the production of protein isolates.

Maximum extractability of the nitrogen is a necessary prerequisite to the production of a protein isolate. Any decrease in the solubility of the native proteins will be an economic disadvantage. A recent comparative study 4/ at our laboratory has shown that only 24 to 46 percent of the nitrogen could be isolated from a prepress solvent meal with a "nitrogen solubility" of 74. The isolation by the same procedures from laboratory defatted glandless and glanded meals ranged from 60 to 76 percent and 42 to 82 percent, respectively. Analysis on the basis of molecular weight and electrical charge on the molecule showed that the major difference between the isolates from the commercial meal and the laboratory meals was the absence of the low-molecular weight, water-soluble proteins.

Recently, a two-solvent extraction procedure based on the solubility characteristics of the two major classes of cottonseed proteins has been developed and evaluated on a pilot-plant scale. 5/ No technical difficulties were encountered. The process provides two protein isolates with widely differing chemical and physical properties. One is composed of the low-molecular weight water soluble pro-

4/ Berardi, L. C., Martinez, W. H., Gajee, B. B., and Fernandez, C. J. A Comparative Study on the Preparation of Cottonseed Protein Isolates I Method of Chemical Composition. Amer. Chem. Soc. Abst. of Papers, 154th mtg., Chicago, Ill., September 1967, A83.

5/ Martinez, W. H., Berardi, L. C., and Fernandez, C. J. Patent Appl. Southern Utilization Research and Development Division, U.S. Dept. Agr. 1968.

teins which have a range of minimum solubility from pH 3.8 to pH 4.2. The second isolate is composed of the storage proteins which are high in molecular weight and have a minimum solubility range from pH 6.2 to pH 7.8. The excellent solubility of this product at an acid pH should be a real advantage in the food markets.

It is apparent that any of the three major steps in processing would significantly reduce the possibility of producing two such protein isolates.

This entire discussion can be summed up in the statement that the method of choice for defatting cottonseed for the production of high-protein products is a direct solvent extraction of flaked seed without cooking using vapor phase desolventization. The seed of choice is glandless cottonseed.

DISCUSSION

Question: Do you know the PER of the cottonseed protein versus casein?

Mrs. Martinez: Cottonseed flours have been produced at the laboratory which gave PER values which were not significantly different from casein. So, the value is quite high. The PER value was above 2.

PRINCIPLES AND THEORY OF LIQUID CYCLONE OIL SEED PROCESSING

by
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(Presented by P. L. Stavenger)

INTRODUCTION

Economical methods for removing gossypol from cottonseed have long been the need of the processor. Tests with liquid-solid cyclones show that this type of simple equipment can perform this function as well as the solvent extraction function.

Over the last 20 years, liquid-solid cyclones have become well established and valuable tools for the classification of solid particles suspended in liquid media. Although liquid-solid cyclones were known and tested in the late 1800's commercial development really did not start until the late 1940's. An extensive development program carried out by the Dutch State Mines in Holland resulted in the first application of the liquid-solid cyclone in coal washeries. This application was rapidly followed by many installations in metallurgical processes. In the early 1950's small diameter cyclones were first applied in the starch processing industry. Today, it would be safe to say that there are thousands of units in operation throughout the world.

In the food industry, the principal application of the cyclone is in the starch wet milling flowsheet. Their potential use in the oilseed processing industry is just now beginning to be realized, and it is our purpose in this paper to outline those fundamentals of cyclone operation that are pertinent to further expansion of this use.

PRINCIPLES OF OPERATION

Figure 1 illustrates the principle of operation of the liquid-solid cyclone. The feed, a suspension of solid particles in a liquid medium, is supplied under pressure through a tangential feed opening. This establishes, within the cyclone, a swiftly rotating body or vortex of fluid. Centrifugal forces in this vortex cause the heavy particles to move to the wall of the cyclone, while the light particles and most of the liquid are forced toward its axis. Nontangential currents, shown in figure 2, cause the heavy particles that have been thrown to the wall to move down toward the apex, where they are discharged. The bulk of the liquid, which contains the fine particles and particles lighter than the liquid, moves vertically along the axis of the cyclone and is discharged out the overflow opening or vortex finder.

A cyclone separates particles on the basis of their size and specific gravity, and the specific gravity of the liquid in which they are suspended. The shape of the particles is also a factor in determining the size of separation. The cyclone diameter, feed inlet and vortex finder dimensions, and operating conditions (usually summarized as pressure drop from feed inlet to overflow) on the other hand, will determine the size of separation from a given slurry.

In general it can be said that the diameter of separation will vary inversely as the square root of the difference in specific gravity between the liquid and the solids and directly as the square root of the viscosity of the suspending liquid. In other words, for practical purposes, it can be assumed that the Stokes' relationship holds for liquid-solid cyclones.

In the food processing industry, cyclones are sometimes referred to as thickeners; however, there is a distinction between thickening and classification which is helpful to the understanding of the cyclone. In what is called thickening, solid particles in the feed tend to hold together by surface attraction during the sedimentation process. In the liquid cyclone, on the other hand, such holding together is not possible because of the very high shearing forces, which disperse loosely held particles or flocculated material. Thus, in the truest sense, a liquid-solid cyclone is a classifier.

This observation is particularly pertinent to the application of the cyclone in oilseed processing. Many of the solid particles we want to separate are colloidal in nature and do not form rigid and substantial structures in the context of cyclone performance. Separations produced in cyclones, therefore, are determined by the smallest particle size of the nonflocculated solid matter. The high shearing forces which develop in cyclones, on the other hand, are of substantial assistance in effecting additional mechanical separation of adhering particles. This has been found to be true, for example, in the processing of cornstarch, and will be seen to be true in the latter part of this discussion where removal of gossypol glands is discussed.

The critical dimensions in a cyclone with respect to separation and separation efficiency are the feed inlet and vortex finder diameters. It has been found that for a cyclone of any given diameter there

Figure 1. Operating principle of the liquid cyclone

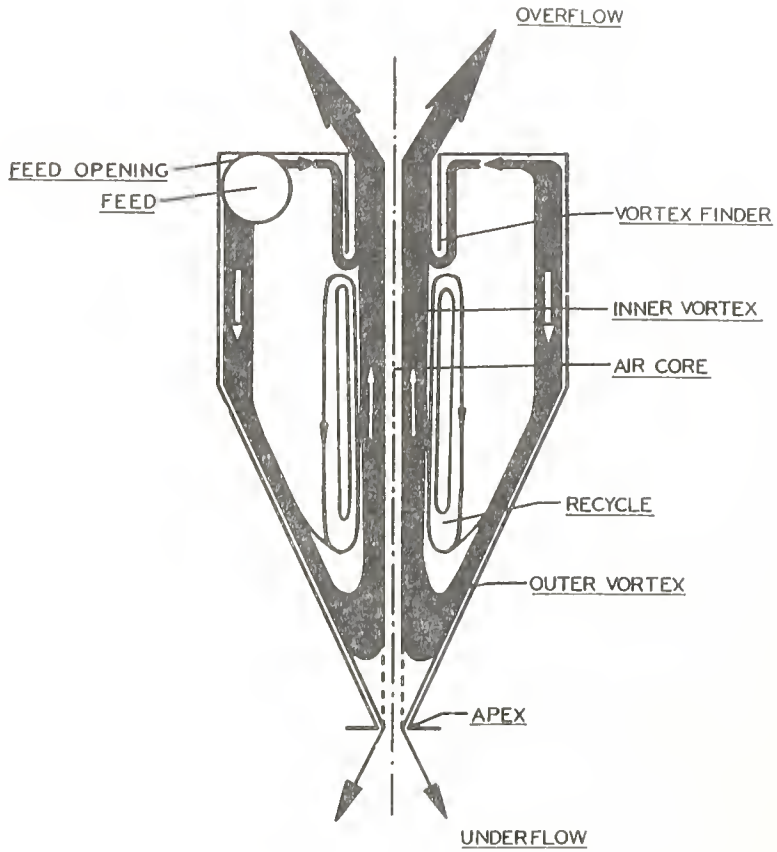


Figure 2. Non-tangential currents in a liquid cyclone

is a set of feed inlet-vortex finder dimensions which provides a minimum diameter separation. Cyclones having these dimensions are referred to as "optimum cyclones." Almost all commercially available cyclones have feed inlet-vortex finder openings that lie within the so-called optimum range. Optimum dimensions of the feed inlet diameter are in the range of 1/5 to 1/7 of the cyclone diameter and of the vortex finder in the range 1/7 to 2/5 of the diameter of the cyclone.

It is obvious, therefore, that if one uses optimum cyclones, the diameter of separation which can be produced is a function of the diameter of the cyclone. In other words, once the separation size is determined for the problem in question, it is necessary to choose the cyclone diameter which produces this separation. Then multiples of this size must be used to accommodate the required process capacity. Table 1 shows the range of separations produced on quartz gravity solids suspended in water for cyclone diameters in the range of 0.4 inches to 24 inches. Using the Stokes' relationship mentioned previously, it is possible with these reference points to predict separations with materials having specific gravities different from quartz suspended in liquids with specific gravities different from water.

Table 1.—Performance of cyclones

Cyclone diameter	Separation diameter	Capacity range	Pressure
Inches	d_{95} 1/	G.p.m./cyclone	P.s.i.
0.4	5	0.9 - 1.25	40 - 100
2	15	10 - 20	40 - 40
6	23	30 - 70	15 - 40
12	48	50 - 100	10 - 30

1/ Quartz (2.7 sp. gr.) in water 8:1 or higher diameter of particle which reports 95 percent to the underflow.

The hydraulic capacity of a liquid-solid cyclone is also determined by the diameter of the feed inlet and vortex finder for a given pressure drop between a feed inlet and vortex finder. For a given cyclone with fixed feed inlet and vortex finder dimensions, operated with underflow rates in the range of 5 to 30 percent of the feed, the capacity will vary essentially as the square root of the pressure drop between the feed inlet and vortex finder. In Table 1 we have also tabulated the capacity range and pressure drop range for cyclones having diameters from .4 inches to 24 inches. The capacity as a function of pressure drop is given in figure 3 for individual optimum cyclones having diameters from 0.4 inches to 24 inches.

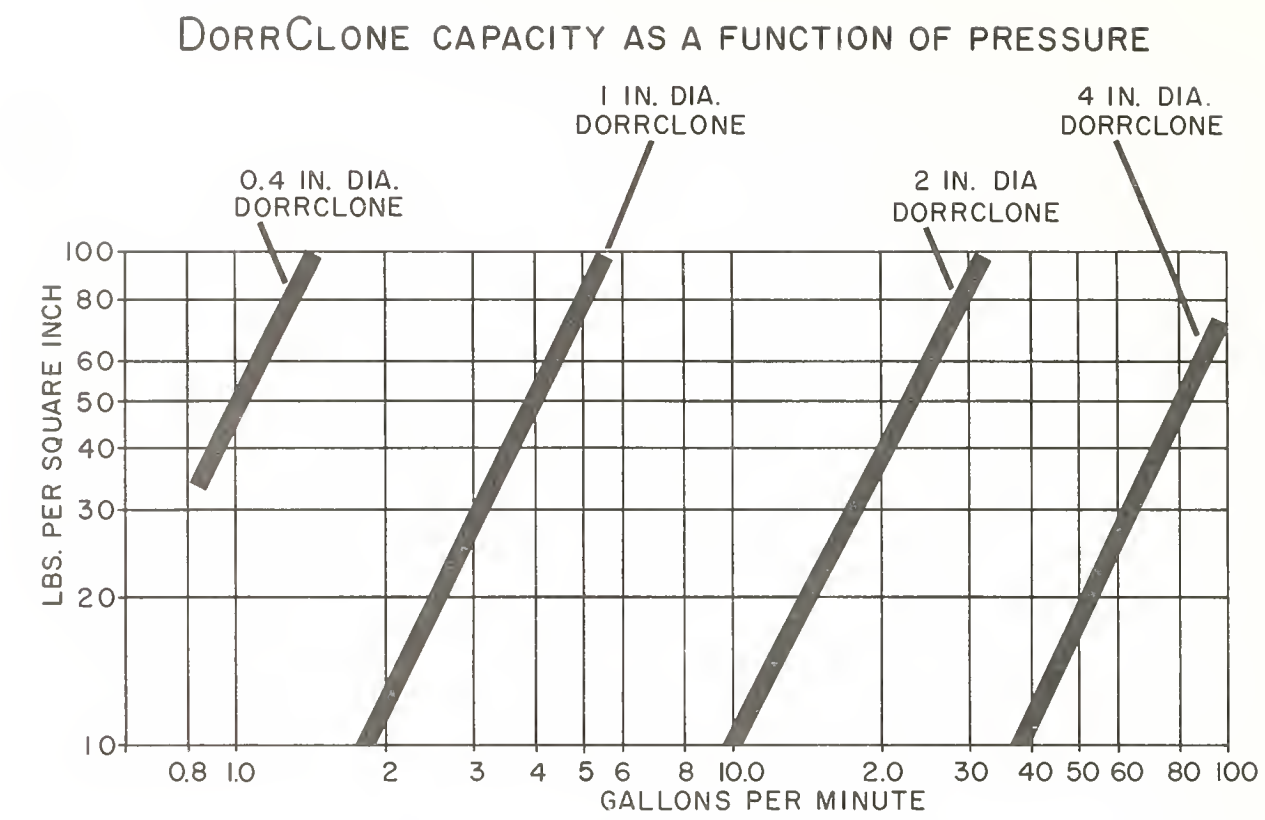


Figure 3. Capacities of optimum cyclones as a function of pressure drop

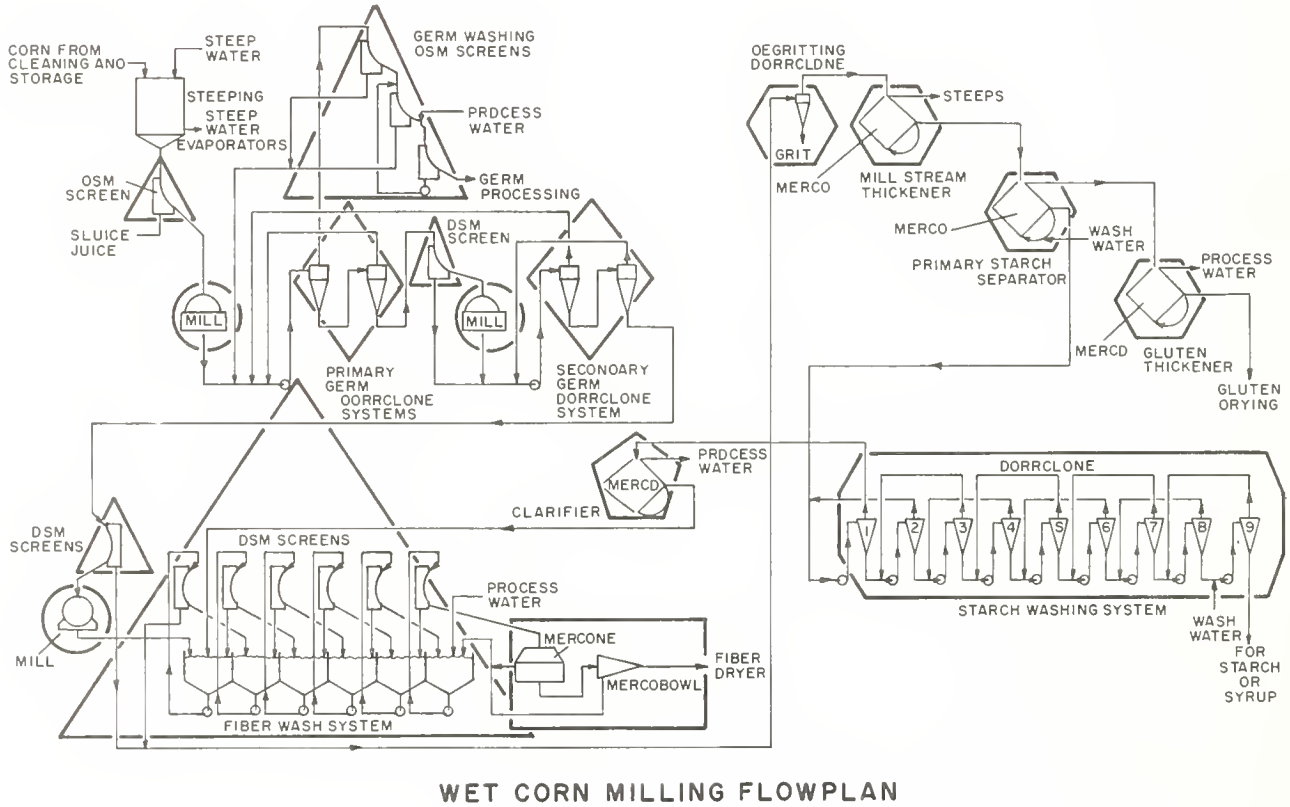


Figure 4. Typical starch flowsheet

APPLICATION

As we have mentioned, the most important application of liquid-solid cyclones in the food industry has been in the starch wet milling process. Let us review its use in starch wet milling as an aid to understanding applications in oilseed processing.

Figure 4 is a simplified schematic flowsheet of the starch wet milling process. This process involves the softening of corn kernels by means of suitable chemical and thermal conditions, followed by a series of mechanical separations resulting in the fractionation of the several components of the corn kernel.

The first step is the separation of the oil-bearing fraction or germ from the rest of the magma. The steeped corn is first macerated in a degerminating mill to release the germ from the bulk of the adhering corn kernel. The released starch forms a suspension, which acts as a dense medium, making possible flotation of the germ in two 2-stage liquid solid cyclone systems.

This separation is based on a specific gravity difference. The germ, a large particle, has a specific gravity of about 1.06 so that it floats on the starch suspension, which has a specific gravity on the order of 1.07. The strong shearing effects of the cyclone tend to release fragments of the corn kernel from the germ, permitting high recovery of this valuable oil-bearing fraction. The 2-stage system is employed in order to obtain a relatively pure germ fraction in the overflow and a relatively germ-free underflow fraction.

The degerminated magma then flows to a series of milling and screening separation steps for the removal of the fiber. This leaves a suspension containing starch particles which vary in size from 2 to 25 microns, very fine fiber fractions, and the gluten, which is colloidal. This mixture, known as mill starch, is passed first through a liquid solid cyclone for the removal of contaminating particles which might damage or plug centrifuge nozzles. Primary separation of the starch from gluten is then effected in a nozzle centrifuge. The gluten overflow fraction is subsequently concentrated in other centrifuges of somewhat different design. The underflow from the centrifugal separation is a starch milk having a density of 18° to 20° Be′ and containing from 1 to 1.5 percent insoluble protein. This material is passed through an 8 or 9-stage countercurrent washing system comprised of batteries of 10 millimeter diameter cyclones. The cyclones concentrate starch in the underflow and remove the residual quantities of protein through the overflow. This operation is a typical countercurrent washing system with the cyclones acting as a concentrating device. The feed material to be washed enters at the left side of the system, is concentrated, rediluted, and reconcentrated in successive stages. Water moves countercurrent to the flow of starch solids, carrying with it soluble and insoluble components. Again in this system the removal of some of the insoluble components is enhanced by the strong shearing effects which exist in the small diameter units. Adhering particles of gluten are mechanically sheared from the starch particles. Some benefit is also obtained in the separation due to specific

gravity effects. That is to say that some of the insoluble components float on the starch suspension.

The starch washing system is a good example of how large numbers of small diameter cyclones can be manifolded. Figure 5 shows a typical commercial installation. It is not uncommon to find manifolds of cyclones containing as many as 2,500 individual 10-millimeter cyclones in each of 8 or 9 stages. This system has proved to be a practical and workable system offering tremendous advantages in reduced capital costs plus ease of control of the process and of product quality. Underflow concentration is controlled by varying the back pressure on the underflow chamber of the cyclones. In the manifolded system, this control is exercised through a single valve on the underflow line. These systems, to a large extent, tend to be self regulating with respect to the transport of starch through the process.

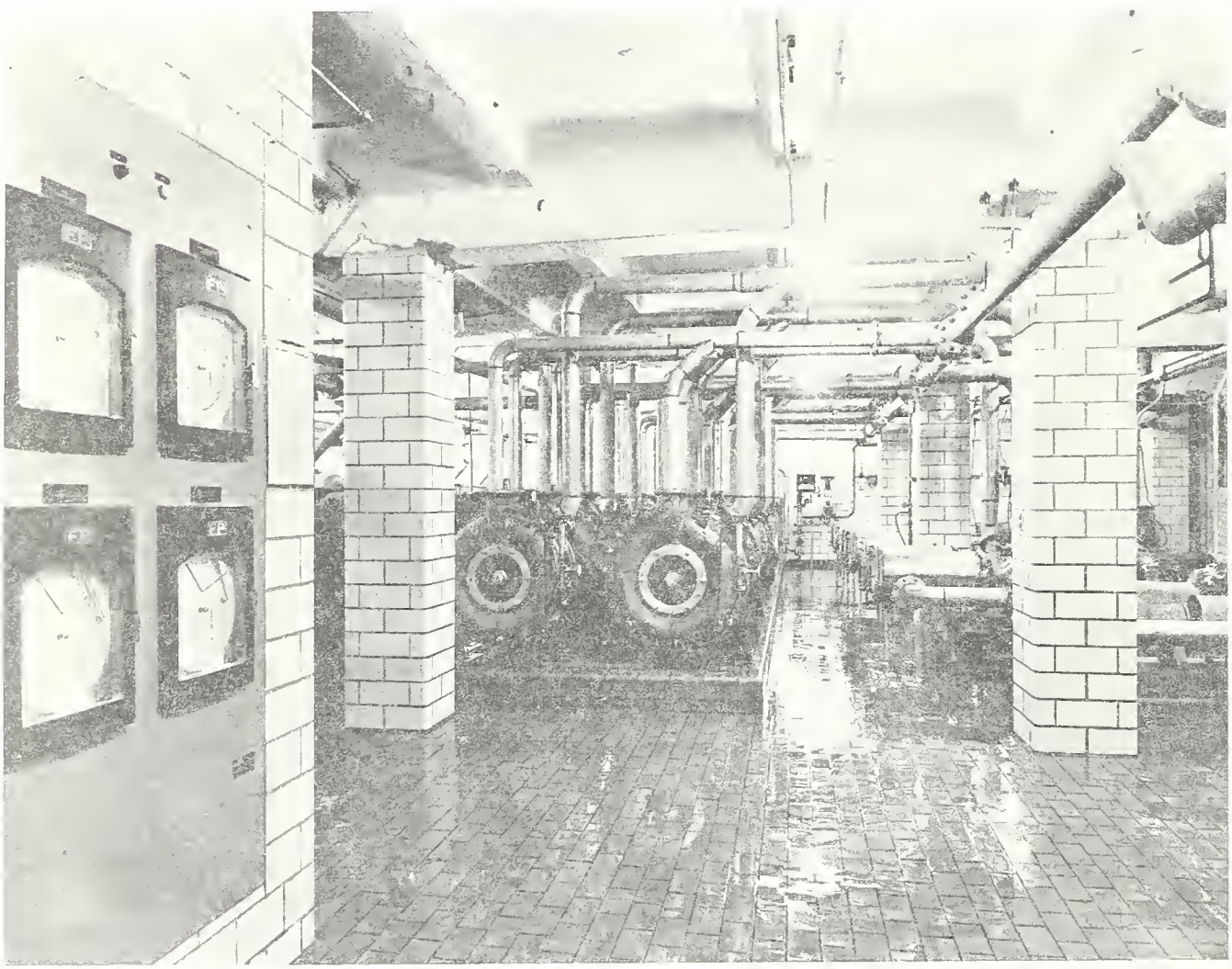


Figure 5 Typical starch washing installation.

USE OF CYCLONES FOR REMOVAL OF MARC

Some use has been made of liquid-solid cyclones in the separation of solids from full miscella in conventional solvent extraction plants. Here the hexane solution of the vegetable oil passes through the cyclone for the purpose of removing small quantities of residual marc. The objective, of course, is to alleviate fouling conditions in subsequent solvent stripping operations. In general, the larger diameter porcelain units pictured in figure 6 have been used for this service.

Oil, rendered soluble in suitable solvents, can be washed from oilseeds in liquid-solid cyclones in the same manner as water-soluble impurities are washed from starch. Tests were conducted on ground decorticated cottonseed to determine the technical and economic feasibility of this service application. While cottonseed was used in the testwork, almost any oil seed, such as soybeans, groundnuts, etc., should give corresponding results.

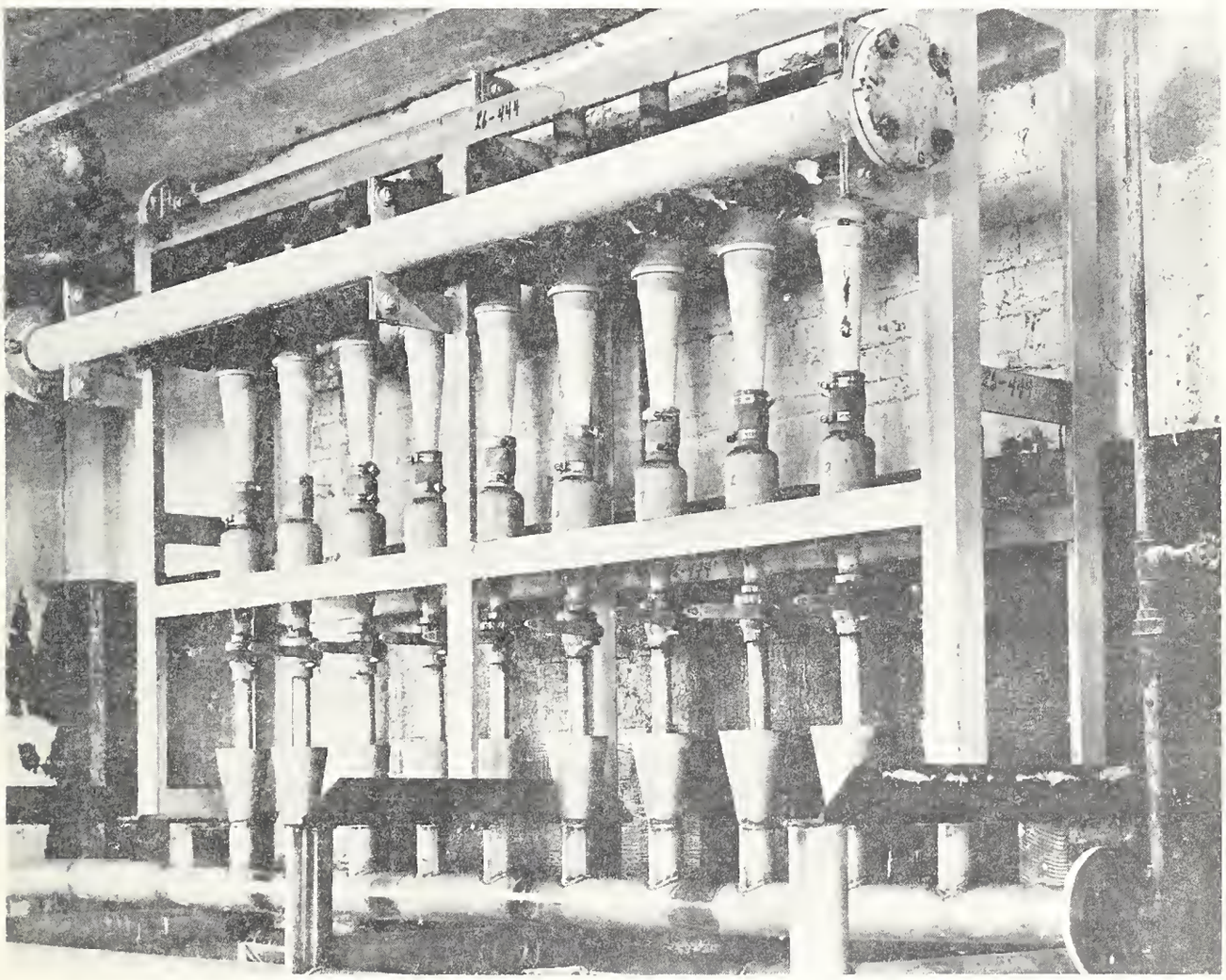


Figure 6. Procelain cyclones of the type used for the removal of marc.

The major objective of these tests was to study the use of liquid-solid cyclones in mixed solvent extraction of oil seeds. This process, developed by the Southern Regional Research Laboratory, USDA, and described by Frampton and others,[1] uses an acetone-hexane-water azeotrope in the extraction process. Free gossypol is reduced to save values by this method. A mixed solvent comprising an acetone/hexane/water ratio of 39/60/1 as suggested by Gastrock and others[2] was employed in the test-work. It would be expected that mixed solvents of other compositions of pure solvents alone would have the same results as long as sufficient detention time was provided ahead of the liquid-solid cyclone washing stages to insure that all the oil was in solution.

Decorticated seed was ground in a dry mill to minus 1/8 in size. Moisture of the ground seed was adjusted to 14 percent. The material was taken up in the mixed solvent at various dilutions and passed through large diameter porcelain cyclones as shown previously. The feed, overflow and underflow, products were analyzed for solids concentration on a bone-dry, oil-free (BDOF) basis.

Table 2 presents the basic data derived from the testwork. Countercurrent washing calculations were made to determine the number of liquid-solid cyclone wash stages required to reduce the oil in the product to 1.0 percent and less. These calculations were based on the data derived from the testwork.

Table 2.—Basic test data - CCW of oil from cottonseed

Ground decorticated seed:			
Moisture	—	14 percent	(0.255:1 dilution)
Oil	—	31.1 percent	(0.565:1 dilution)
Dry solids	—	54.9 percent	
Seed "as is" dilution = 0.549 BDOF dilution			
Oil in product miscella			— 20 and 25 percent
Oil in product meal			— 1 and less percent
DorrCone underflow dilution			— 2.35:1
Centrifuge underflow dilution			— 0.538:1

1/ Frampton, V. L., Pepperman, A. B., Jr., Simmons, J., and King, W. H. Countercurrent Extraction of Raw Cottonseed Flakes with the Acetone-Hexane-Water Azeotrope. Jour. Agr. Food Chem. 15: 790-797. 1967.

2/ Gastrock, E. A., D'Aquin, E. L., Keating, E. J., and others. A Mixed Solvent-Extraction Process for Cottonseed. Cereal Sci. Today 10: 572-574, 598-599. 1965.

Figures 7 and 8 present the countercurrent washing calculations by a method described by Fitch. 3/ All values given in these calculations are relative dilutions based upon 1,000 unit weights of dry solids with values "x" being relative weights of oil on the same basis. Values derived in figure 7 are based upon producing a full miscella containing 20 percent oil; those in figure 8, upon producing a full miscella containing 25 percent oil. These values were chosen as limits of oil concentration for economical oil desolventization.

Values derived from the countercurrent washing calculations are presented in graphical form in figure 9. Depening on the desired concentration of oil in the full miscella, 5 to 6 stages of liquid-solids cyclones would be required in the countercurrent washing extraction system to produce a meal containing less than 1.0 percent oil. Six to 8 stages would produce a meal containing less than 0.4 percent. In all cases, the liquid-solid cyclones would be followed by a solid bowl centrifuge to dewater the meal to a final solids concentration of 65 percent. This final solids content is consistent with economical meal desolventization.

All systems considered are considerably less expensive than conventional systems. Cost of equipment used in the seed preparation and extraction steps of a 200 t.p.d. conventional plant was estimaded in 1964 to be $200 thousand by the United States Department of Agriculture. 4/

An 8-stage liquid-solid cyclone system followed by centrifuges for the same capacity would have an equipment investment of $123 thousand. This investment includes the liquid-solid cyclone, centrifuge, dry grinding mill, conveyors, pumps, and interconnecting piping.

These systems would provide even greater savings over the conventional system when compared on an installed basis because of savings in space and simplicity in installation of the units.

3/ Fitch, Bryant. Countercurrent Filtration Washing. Chem. Engin. 69(2): 119-124. 1962.

4/ Decossas, K. M., Molaison, L. J., Gastrock, E. A., and Vix, H. L. E. Conversion of Direct Hexane Extraction Plants Acetone-Hexane-Water Extraction of Cottonseed: Preliminary Cost Study. 1964. [Manuscript]

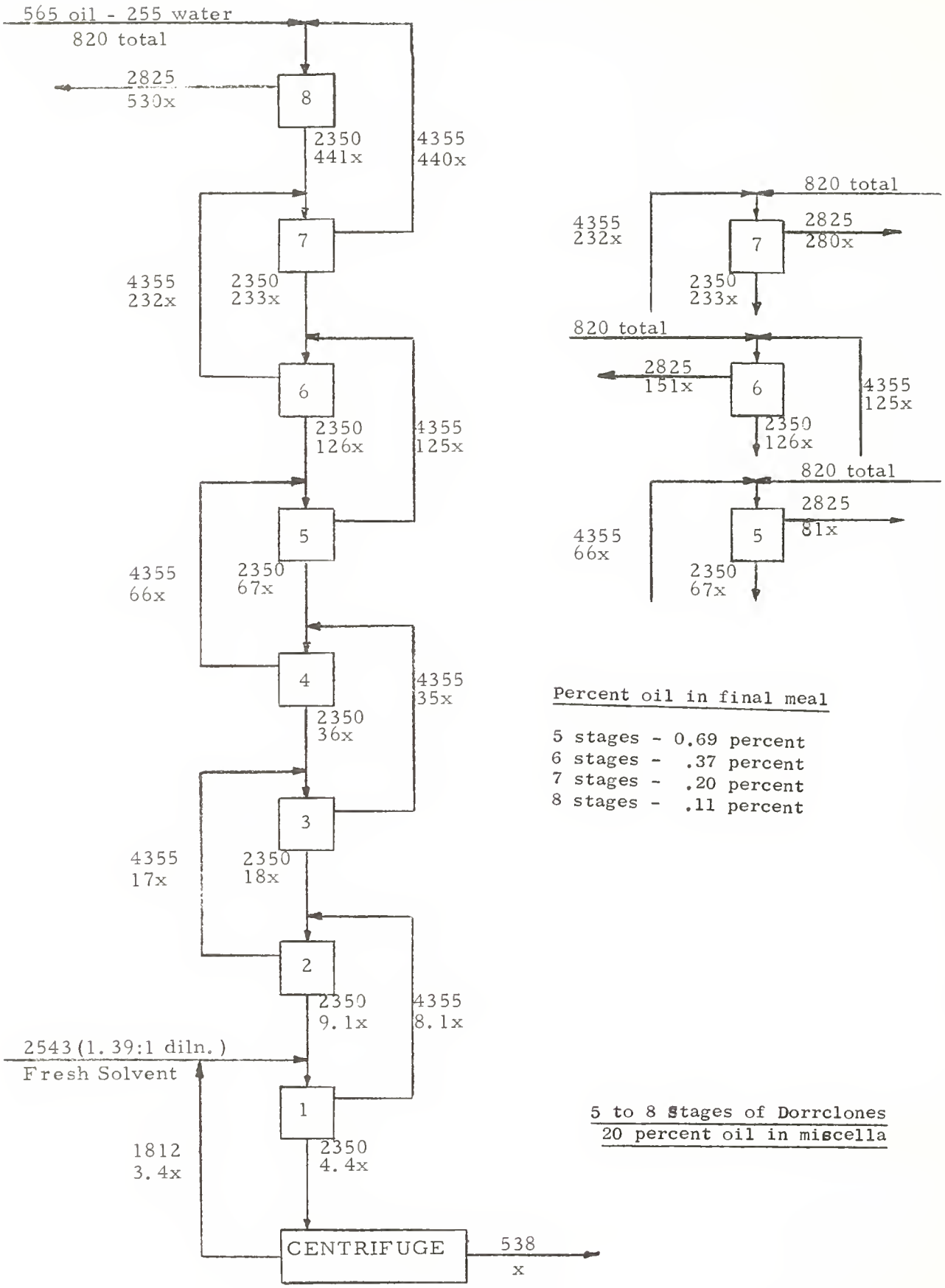


Figure 7. Countercurrent wash calculations, 20 percent oil in miscella.

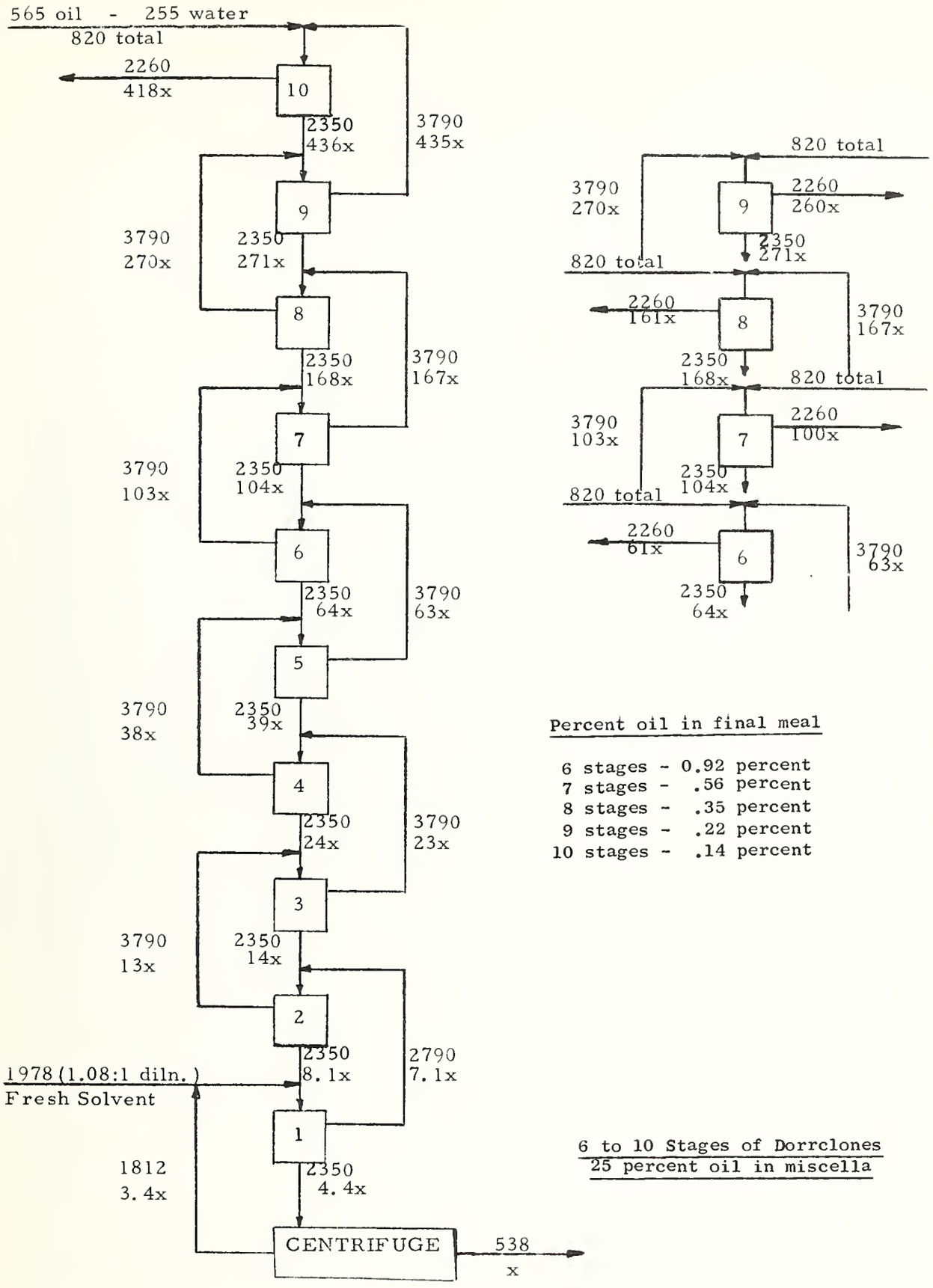


Figure 8. Countercurrent wash calculations, 25 percent oil in miscella.

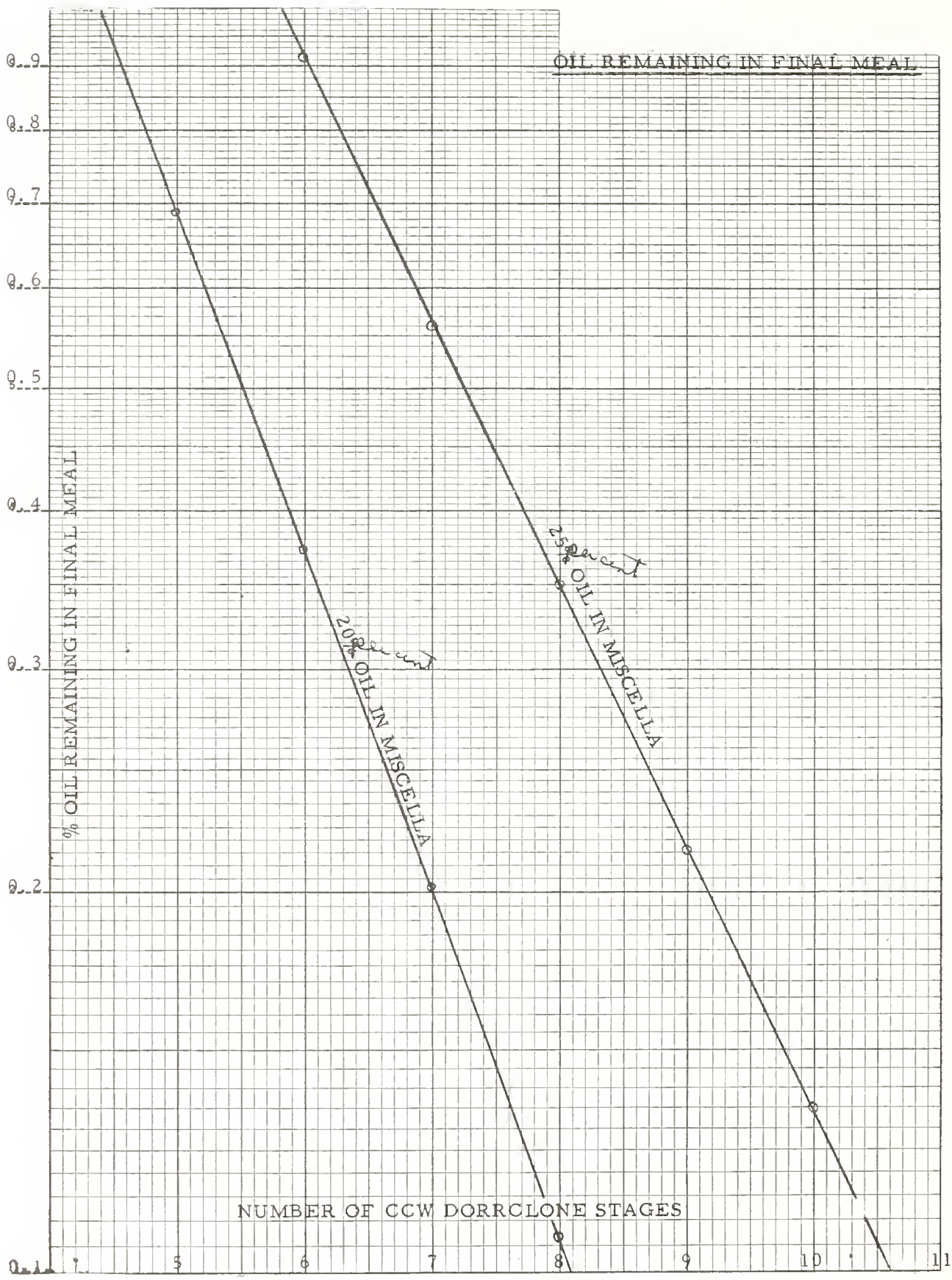


Figure 9. Oil remaining in final meal.

Liquid-solid cyclones of 50-millimeter and 10-millimeter diameters have been used successfully to separate gossypol-bearing pigment glands and other non-protein fractions from protein in defatted cottonseed. The next paper presented by Mr. Gastrock will deal exclusively with this subject.

The photomicrographs, figures 10 to 13, show that in a plus 65 mesh fraction of ground seed parts of the hulls are imbedded in the meat, but these hull fragments are readily separated by the large diameter liquid cyclones. In both this and the finer -65 +100 mesh fractions, the pigment glands are imbedded in the meat. In the -100 +150 mesh fraction, however, the pigment glands are separated from the meat, enabling the liquid-solid cyclones to separate them from the protein. In all of these photomicrographs the pigment glands are seen whole, and small glands, still whole, are visable in the -200 +325 mesh material. Even these smaller glands can be separated from the meat in the cyclones.

These photomicrographs indicate that a preferential grinding takes place when defatted cottonseed is ground in the presence of hexane. The meats of the seed, being harder, are ground to a finer fraction while the bulk of the tougher pigment glands remain whole. Thus the pigment glands are larger than the ground meat, which permits the physical separation of the glands from the protein by liquid-solid cyclones.

A further phenomenon of this physical separation is a dense medium effect set up by concentration of the protein slurry in passing from one set of small diameter cyclones to the next. The protein fraction reporting to the underflow of each stage is further purified by elimination of the finer fractions of pigment glands and other nonprotein material of lower specific gravity out the overflow.

DISCUSSION

Question: Did you say that the velocity in the core is much greater than the velocity at the wall of the cyclone?

Mr. Stavenger: Yes, as you go toward the center of the cyclone, the rotational velocity increases—just as though you are on ice skates and you bring your arms in. Momentum is conserved, so the highest velocity in the cyclone exists in the core.

I should have mentioned that there are some reprints of this paper which can be passed out and rather than burden you with some of this detail, I would suggest that you read over this paper and I will be around to answer any questions.

Question: You don't break up the gossypol cells in grinding beyond 200?

Mr. Stavenger: Not if you condition them to 4 percent moisture and grind them in hexane.

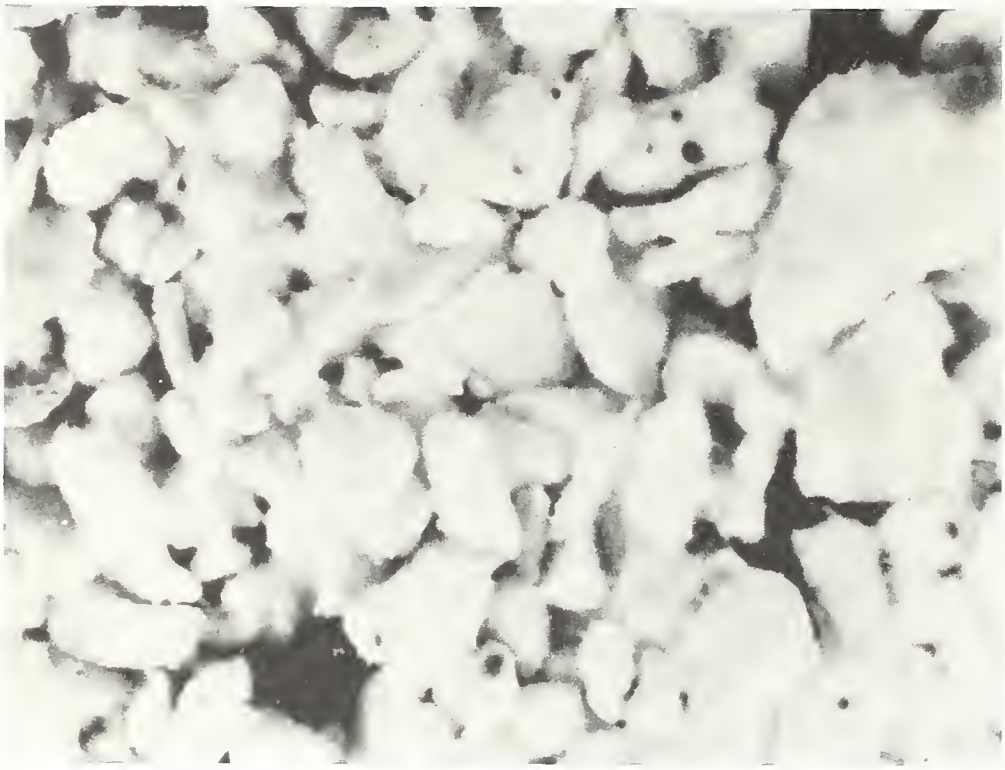


Figure 10. Photomicrograph +65 mesh, 30 x.

Figure 11. Photomicrograph −65 +100 mesh, 30 x.

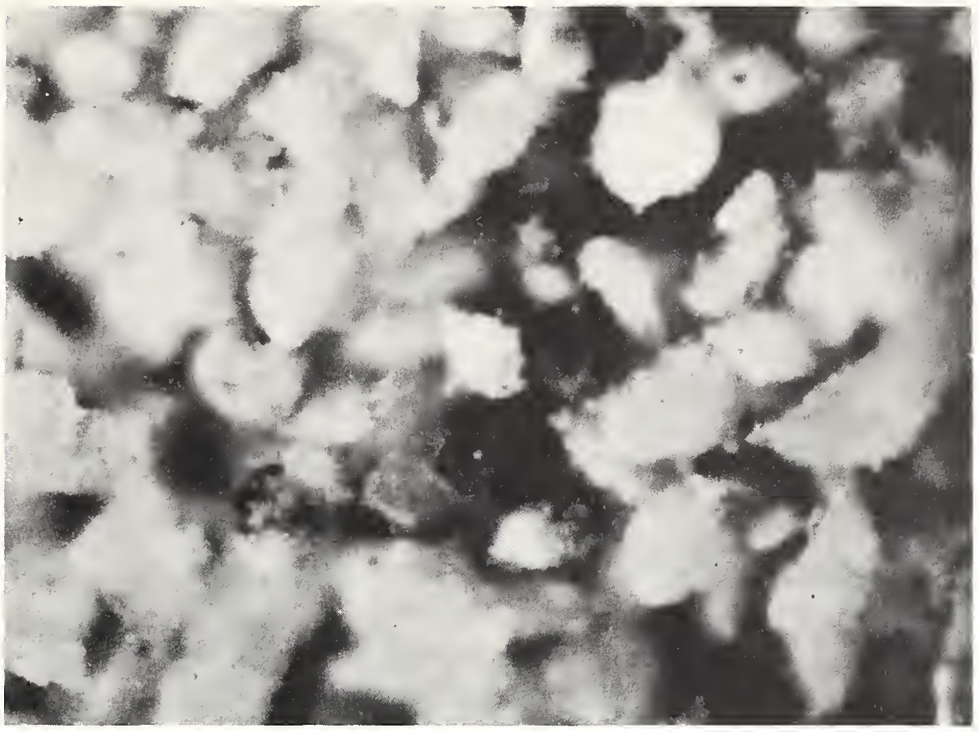


Figure 12. Photomicrograph –100 +150 mesh, 75 x .

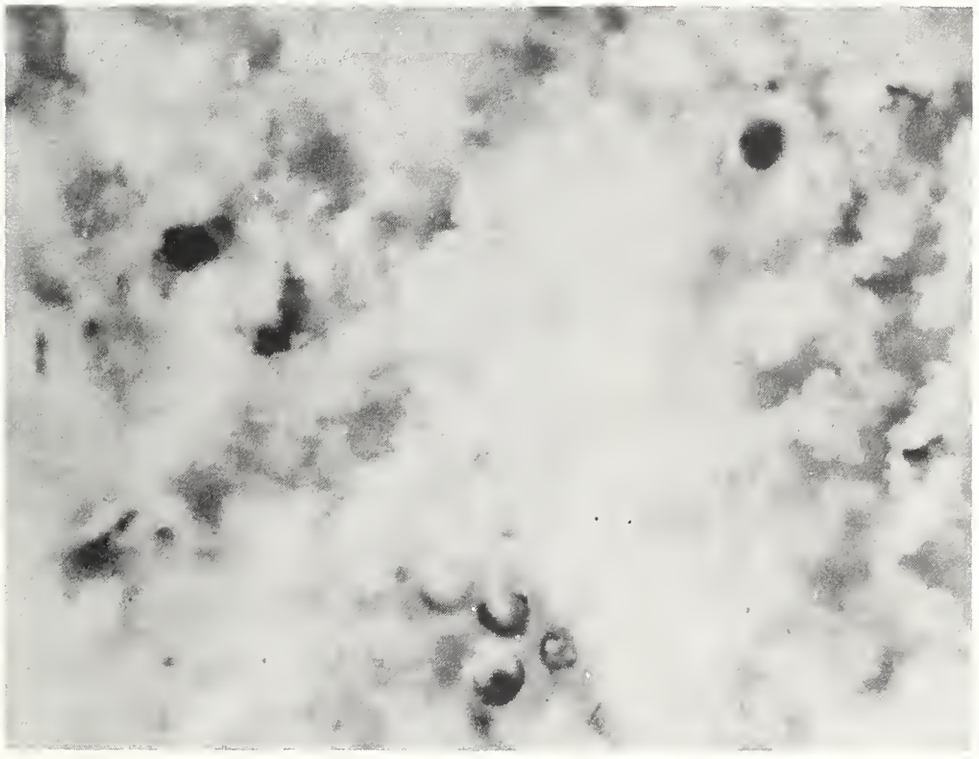


Figure 13. Photomicrograph –200 +325 mesh, 75 x

THE APPLICATION OF THE LIQUID CYCLONE TO THE PRODUCTION OF HIGH—QUALITY COTTONSEED FLOUR

by
E. A. Gastrock
Southern Utilization Research and Development Division

The high-quality edible cottonseed concentrate produced by the liquid cyclone process has the following typical analysis:

Protein (nitrogen X 6.25)	70.0 percent
Protein solubility (in 0.02 N NaOH)	98.0 percent
Lipids	0.6 percent
Gossypol, free	< 0.05 percent
Gossypol, total	< 0.30 percent
EAF Lysine	3.85 g. per 16 g. N
Flavor	bland
Color	light cream

Because of its high protein content, 70 percent, the protein product is a concentrate,, by definition, and not a flour. An edible protein product of such high quality cannot be produced from glanded cottonseed by processing methods, solvent or mechanical, now in use by oil mills. A brief look at a flake produced from glanded cottonseed kernel will tell us why (figure 1).

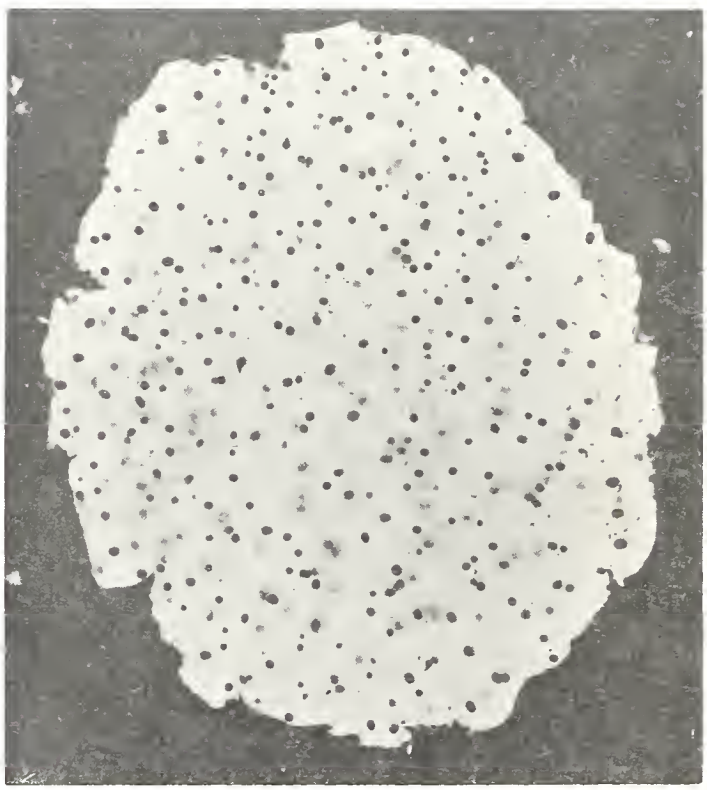


Figure 1. Flake produced from glanded cottonseed kernel.

Glanded cottonseed structure.—The black dots scattered throughout the flake are pigment glands (1). These glands are ovoid sacs and contain 35 to 50 percent of gossypol. They constitute about 2.4 to 4.8 percent of the weight of the dehulled cottonseed kernels. The gossypol content of these kernels will vary between 0.8 and 2.0 percent total gossypol. The glands are from 0.001 to 0.007 inches in diameter, rather tough, and somewhat resilient. They resist mechanical damage well under certain conditions, but water and polar solvents rupture them.

Current processing methods utilize various combinations of moisture, heat, and pressure that result in gland breakage and spillage of their gossypol content which is then picked up by the oil or protein products. In the oil it is responsible for color problems. In the meal it appears as "free" (4) and "total" (5) gossypol. Speaking broadly, the difference between "total" gossypol and "free" gossypol is termed "bound" gossypol and represents gossypol that has combined with some meal component. The usual combination is with the important essential amino acid, lysine, thereby rendering it unavailable nutritionally and reducing the nutritive value of the product.

The problem.—Ideally we would like to separate the cottonseed into five separate products, none of which would be contaminated by any of the other. These five products are linters, hulls, oil, protein product, and intact pigment glands.

1. We remove most of the linters with the linter saws.

2. We remove a large part of the hulls in the dehulling operation, but, in order not to lose protein and oil, a sizeable amount of hulls remains with the various fractions of dehulled meats.

3. The problem then is to avoid breaking the pigment glands while the oil is removed from the meats or flakes by an inert solvent such as hexane. This would result in a light-colored oil.

4. Having done this, the next problem is to comminute the extracted kernels without rupturing the pigment glands and then to separate the remaining hull particles from the protein meal tissue and pigment glands as completely as possible by mechanical means. The material then remaining would be separated into a light-colored, high-protein product substantially gossypol-free and a gossypol-rich protein product.

Research and Development Approaches

Previous investigations.—Nearly 20 years ago two approaches were investigated. These were flotation (7) and differential settling (6).

In the flotation process the cottonseed flakes, having been properly conditioned, are disintegrated in a unit like a Waring Blendor in a mixture of chlorinated and nonchlorinated hydrocarbon solvents adjusted to a sp. gr. of 1.378. The diluted slurry (sp. gr. 1.378) is allowed to stand, whereupon the pigment glands rise to form a layer on top of the solvent to be skimmed off and the rest of the disintegrated material—

protein, hulls, and partially disintegrated meat particles—sinks to the bottom.

In the differential settling process, the cottonseed flakes, having been properly conditioned, are disintegrated in a unit like a Waring Blendor, but in hexane only. The diluted slurry is also allowed to stand, but the hull particles, coarse meal, and pigment glands sink rapidly to the bottom and the finely divided protein particles being slow settling are siphoned off. The National Cottonseed Products Association supported the differential settling process research with two fellows, C. G. Reuther and N. B. Knoepfler. Both later joined our staff. Mr. Knoepfler is still with us.

The Liquid Cyclone Process

The liquid cyclone process (LCP) (figure 2) is a further development of the mechanical separation process which:

1. Uses substantially the whole meats stream from the hullers;

2. Reaffirms the necessity for initial conditioning of the meats to below 4.0 percent moisture before flaking, extraction, and comminution;

3. Provides a feasible hexane extraction process for the pre-dried meats and flakes;

4. Introduces a necessary fluidizing step, preliminary to comminution;

5. Introduces a new concept of comminution using a high-speed stone mill;

6. Provides an improved screening technique, whereby hulls are removed from the system; an intermediate coarse fraction is separated for recycling and regrinding; and a fine fraction is provided for subsequent separation in liquid cyclone into two fractions: (1) a concentrated pigment gland fraction, and (2) a purified fraction high in protein, low in gossypol;

7. Introduces the use of 50 mm. (P50) liquid cyclones for separating as overflow a purified, essentially gland-free protein slurry and as underflow a gland-rich high-gossypol protein fraction;

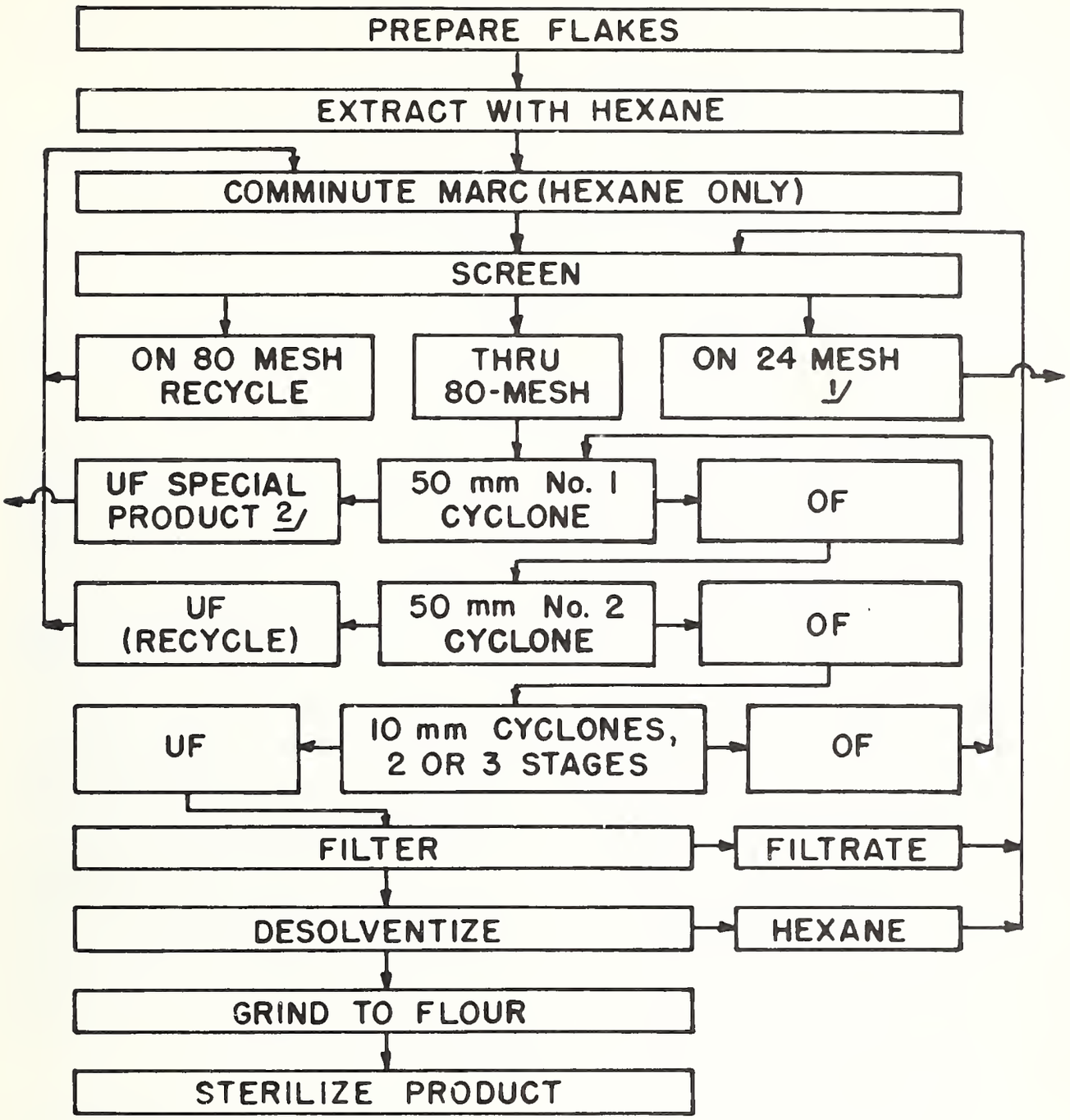
8. Introduces the use of 10 mm. (Doxie) liquid cyclones, in 2 or more stages, to concentrate the purified, essentially gland-free protein slurry to about 30 percent total solids content;

9. Introduces the concept of vacuum filtration of the concentrated protein slurry so formed to produce a filter cake of about 50 percent solvent content at commercial rates on commercial-type equipment;

10. Proposes desolventization of the filter cake thus produced in commercial-type dryers;

11. Introduces the concept of recycling appropriate streams to the process for additional comminution, screening and separation to increase the yield of purified protein product.

Grinding and packaging of the product would follow conventional methods.



OF = OVERFLOW UF = UNDERFLOW

1/ CAN BE REGROUND & SCREENED TO RECOVER MORE PROTEIN.

2/ HIGH GOSSYPOL CONTENT

Figure 2. Liquid cyclone process for cottonseed.

The product.—The Liquid-Cyclone-Process concentrate (LCP-concentrate) is bland in flavor and has a light cream color. It is free of the unfavorable color and flavor characteristics of cottonseed protein products prepared with solvents containing acetone. Its chemical composition was shown in figure 1.

Quality.—The LCP-concentrate has been used in enriching the protein content of wheat flour bread. Up to 25 percent LCP- concentrate has been added to the formulation of this yeast bread, approximately doubling the protein content to 20 to 22 percent. Texture, flavor, and loaf volume of the bread containing LCP-concentrate were comparable to the same characteristics of bread made only with wheat flour. Similarly, biscuits made with a commercial biscuit mix in which 20 percent of the weight had been substituted by the LCP-concentrate, had an excellent texture and flavor and a creamy, yellowish color.

Considerable information is available at the Southern Utilization Research and Development Division (SURDD) on the nutritive value of AHW-flours (2) and flours or concentrates produced by extraction with aqueous acetone followed by anhydrous acetone (3). The LCP-concentrate has a significantly higher protein content, of equal solubility, than the AHW-flour, but otherwise closely proximates the latter in composition. Comparison with the AA-AA-flour or concentrate closely parallels its composition except that the latter is somewhat higher in free and total gossypol contents. It can be expected, therefore, that the nutritive value of the LCP-concentrate will be equally as high as the AHW- and AA-AA-products without the objectionable flavor and color characteristics of the latter.

Economic considerations.—Very preliminary estimates based on numerous experimental runs at SURDD and translated to the operation of a theoretical plant to process 200 tons of cottonseed per day assume daily yields as follows:

	Pounds
High-protein content concentrate	72,600
High-gossypol content meal	62,000
Oil	72,000
Hulls	145,400
Linters	40,000

Seed costs were estimated at $65.90 per ton and plant operating costs at $20 to $25 per ton. In order to calculate the cost of the high-protein content concentrate, the linters were priced at $60 per ton, the hulls at $22 per ton, the oil at $0.12 per pound, and the high gossypol content meal at $60 to $80 per ton. This yielded a range of costs for the high-protein content concentrate of from 4.5 to 6.75 cents per pound. Soybean protein concentrate sells for 15 to 18 cents per pound.

Discussion

The Liquid-Cyclone-Process for the production of essentially gland-free edible cottonseed concentrate from glanded cottonseed is envisioned as part of a larger plant which produces free-grade meal. The process, however, may also be eventually carried out in a plant designed mainly for the production of good grade concentrate. Regardless of which type plant is used, strict adherence

to sanitary considerations must be observed.

Significant breakthroughs in the process outlined above are as follows:

(1) When meats are dried to a moisture content of 4 percent or lower and flaked, flakes can first be extracted with hexane without breaking the pigment glands. Removal of fines from product miscella is thus eliminated.

(2) Relatively dry flakes (4 percent moisture or less) can be extracted in basket extractors or by filtration extraction at commercial rates. This development could be an improvement over the current and traditional method of direct solvent extraction of cottonseed.

(3) Hull-free meats are not a requirement of the process. Hulls accompanying the meats can be removed later during grinding and screening operations.

(4) Doxies concentrate the overflow from the P50 DorrClones, making it possible to feed the concentrated slurry to a continuous vacuum drum filter operable at commercial rates as high as 50 pounds per square foot per hour.

(5) Approximately 85 to 90 percent of the gossypol present in the seed is removed in the underflow of the first P50 DorrClone. Between 30 and 35 percent of the total protein content of the flakes accompanies the gossypol in this underflow. The underflow from the second P50 DorrClone is recycled, entailing no loss of protein from the system. Total protein diverted to the high-gossypol content product does not exceed 35 percent. It is anticipated that this fraction will be mixed with the meal product of the parent feed mill and used as fertilizer or as a source of gossypol. Thus the process makes possible a yield of fine, edible, high-protein concentrate containing less than 0.30 percent total gossypol, 0.05 to 0.07 percent free gossypol, and 65 percent of the protein originally present in the seed.

The key to the process lies in separating the intact pigment glands from the protein. The pigment glands contain the gossypol. Grinding or comminuting of the flakes slurried in hexane makes possible a mechanical separation in the P50 DorrClone into two fractions, the underflow containing most of the pigment glands (and the gossypol), and the overflow containing most of the protein essentially free of pigment glands.

Prime seed, free of contaminants such as aflatoxins, is a requirement of the process because a food grade product is being manufactured.

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EXTRUSION OF COTTONSEED AND CEREALS

by
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Southern Utilization Research and Development Division

Extrusion studies were started at the Southern Utilization Research and Development Division (SURDD) about a year ago. Products that have been used in the experiments included corn, white and brown rice, glandless and glanded cottonseed, and a combination of cottonseed with corn or rice. To a lesser extent some extrusion work has been done with peanuts and sweetpotatoes.

I plan to emphasize the results obtained by extrusion of a screw-pressed cake consisting of a mixture of glanded cottonseed and corn. I want first to discuss for the benefit of those who are not acquainted with extrusion operations very briefly: (1) What extruders are, including a description of the extruder used at SURDD; (2) extruder uses; and (3) results obtained by extruding corn and rice.

What are extruders?—The type of extruders that we are concerned with are high-temperature, short-time (HTST) processing machines. These are not to be confused with extruders which have been in use for a long time to produce products like macaroni or sausage, in which cases much lower temperatures and pressures are used. A description of the pilot-plant size extruder we have at the Laboratory will give you an idea what these extruders are like.

We have an NRM extruder made by the National Rubber Machinery Co. It has three sections and is designed for use with three different length stainless-steel screws, 28, 21, and 14 inches, each of which is 1-1/2 inches in diameter. The screws are partly hollow for temperature control. The short screw has a variable pitch. The two longer screws have a standard pitch but contain a "balloon valve" in the center to help pressure control. This is accomplished by movement of the screw in a direction parallel to the axis. Pressures can also be controlled at the discharge end by a thread-

ed-screw mechanism. Pressures of over 2,000 pounds are obtained. The heavy walled three-sectional barrel is steam-jacketed for temperature control and the internal lining is designed to help forward movement of the material. Each section has a thermocouple to record temperatures of the food within the machine. The discharge dies are of different designs—1/4-inch hole, two 1/8-inch holes, and 1/16- by 1/2-inch slot to produce different shaped materials. The screw speed is variable from 30 to 120 revolutions per minute (r.p.m.) to control residence time. It is a versatile machine—good for experimental work. Production machines are much simpler.

Extruder uses.—Extruders were initially designed for the extrusion of plastics and rubber. One can purchase from machinery manufacturers extruders especially suited for these purposes just as one could purchase a screw press for expelling oil from oilseeds, whereas the commercial availability of extruders strictly for processing food materials is limited.

Many food companies are using extruders today to produce processed foods for human consumption; however, most of these extruders are either modified, commercially available extruders, or are designed and built by, or under the specification of, the particular food company for a particular use. In most cases, information on these extruders is considered proprietary by the company. I believe we will see increased use of extruders in the food industry in the future.

Extrusion of corn and rice.—Cornmeal was used to conduct the initial exploratory tests. Variations included particle size, moisture contents of 12 to 35 percent, temperature of 225° to 350° F., and retention times based on screw speeds of 30 to 120 r.p.m. As the material discharged from the extruder, it expanded to 1-1/4 inch in diameter from the 1/4-inch dye. This expansion is obtained when the following conditions are used: Moisture in corn meal – 14 percent particle size – between 30 and 100 mesh; temperature in third section – 325° F.; pressure in third section – 2,000 pounds per square inch and screw speed – 80 r.p.m.

Similarly, numerous test runs were conducted using various types of rice—white and brown rice in grit form or as whole rice, brewers rice, and broken grain parboiled rice. I'll mention several interesting products that were produced but will not attempt to discuss the preparation details. (1) The expanded, cylindrically shaped, extruded rice was cut into lengths of 2 to 3 inches and coated with cheese. This product had a finer texture than that produced from corn. (2) The cooked expanded product prepared from brown rice and ground to a coarse size resulted in a tasty product which has potential use as a breakfast cereal—need only to add milk and sugar. (3) By finer grinding of the extruded material, a brown rice flour can be produced. Extrusion processing improves appreciably the shelf life of these brown rice products. (4) White rice flour, similarly produced, is pregelatinized and both flours would be a valuable ingredient for use in beverages and gruel, particularly in rice-eating countries.

Extrusion of cottonseed with corn

or rice.—A series of experiments were conducted whereby mixtures of full-fat cottonseed meats with either corn or rice were extruded. The purpose of these experiments was to produce an edible product eontaining about 20 percent protein with cottonseed as the main source of the protein.

Cottonseed meats used were essentially hull free. The ratio of cottonseed meats to either rice or corn was varied from 1:8 to 1:1, that is, the cottonseed portion was varied from 12.5 to 50 percent of the mixture.

Both glanded and glandless seed were used in these experiments. When glanded seed was used, the free gossypol of the extruded product was decreased by one-half or more, but this decrease was not enough to consider the product edible, so most of this series of experiments were conducted with glandless seed.

Mixtures containing 40 and 50 percent cottonseed could not be extruded because oil release was such that free oil would either back up into the feed hopper or discharge forcibly through the die. Mixtures with 12.5 to 25 percent cottonseed could be extruded satisfactorily in most cases. Consequently, it was deeided that the 20 and 25 percent cottonseed mixtures would be most practical since this would give a product containing about 20 percent protein.

Moisture contents of the mixtures were varied from 12 to 20 percent. Best results were obtained when moisture content of the material was 14 percent.

Pressure within the extruder varied up to about 2,000 pounds per square inch gage (p.s.i.g.) but averaged about 1,200 p.s.i.g. Best temperatures were in the 300° to 350° F. range. The screw speeds were somewhat less than those used when corn or rice alone were extruded, that is about 50 r.p.m. as compared to 80 r.p.m. The reason is believed to be that more retention time is required to gelatinize the rice or corn in the presence of the cottonseed.

There was little or no expansion of the product as discharged from the extruder. The presence of oil, and to some extent the protein, tends to prevent expansion, whereas essentially no expansion was obtained with either white or brown rice.

Extrusion of screw-pressed cake.—Some use of cottonseed for food purposes has been made in developing countries by careful selection of screw-pressed meals of low-gossypol content. A value of 0.06 percent is specified, but at times it has been difficult to locate meals having this low level of gossypol.

The high-temperature, short-time extruder processing conditions used for full-fat, glanded seed indicated that there was the possibility of decreasing the free gossypol in pressed cake to levels acceptable for food use. It was also thought that this could be obtained without apprcciablc detrimental effect on the nutritional quality of the product as measured by the available lysine.

Consequently studies were undertaken to prepare screw-pressed cakes with reduced free-gossypol content and to

subject the screw-pressed cakes to the extrusion operation for further gossypol reduction.

In preparing the glanded meats, elimination of the hulls was necessary to reduce the fiber content. But since fibrous or coarse material is required for successfull operation of the screw press, it was thought that coarse cornmeal grits could be used to replace the hulls.

Five screw-press experiments were conducted using as a feed a mixture of 75 percent glanded cottonseed meats essentially free of hulls, and 25 percent cornmeal.

The range of screw-press conditions was as follows:

	Range of runs No. 1 to No. 5	Run No. 4
Moisture in feed mixture	4.7 to 8.7 percent	4.7 percent
Temperature of feed	162° to 185° F.	183° F.
Steam pressure to trough	35 to 50 p.s.i.g.	36 p.s.i.g.

Analyses of the screw-pressed cakes were:

	Range runs No. 1 to No. 5	Run No. 4
	Percent	Percent
Lipids	7.4 to 13.0	8.6
Moisture	3.2 to 5.3	3.5
N_2	6.1 to 6.8	6.5
N Solubility	81.0 to 83.4	82.5
EAF Lysine	3.6 to 3.7	3.6
Free gossypol	0.06 to 0.18	0.15
Total gossypol	0.58 to 0.78	0.71

Total gossypol in the oil ranged from 1.1 to 1.7 percent.

The screw-pressed cake from run No. 4 would show best the effect of extrusion on reduction of free gossypol since its gossypol content was one of the highest of the five test runs. Therefore, the pressed cake from Run No. 4 was selected for extrusion experiments. Because of the oil removed, the composition of the cake is about 67 percent cottonseed and 33 percent corn.

In conducting the extruder experiments, the moisture in the feed (pressed cake) was varied and adjusted to levels of 8, 12, 16, and 20 percent and extrusion temperatures were varied from 260° to 335° F.

In all cases the free gossypol was reduced to 0.03 percent or below. The total gossypol remained at about the same, that is, 0.60 to 0.66 percent. EAF lysine varied from 3.2 to 3.6 g. per 16 gN and the nitrogen from 6.1 to 6.4 percent.

Some of the screw-pressed cake was mixed with additional cornmeal to give cottonseed-cornmeal ratios of 2:1, 1:1, 2:3, and 1:4, prior to extrusion. The only further reduction in gossypol over that obtained by using the "as is" pressed cake was that obtained by dilution. Similarly other changes in analyses were comparable to the changes in the cottonseed-cornmeal mixtures.

As you can judge from this presentation, this work has been exploratory to determine avenues of research to utilize cottonseed as a high-protein material for food use. It appears the extrusion operations can play an important part in processing cottonseed to produce edible high-protein products.

PROCESSING OF SOYBEANS

by
R. J. Dimler
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I apprcciate being invited to share with you some thoughts about the processing of soybeans. Of course, I cannot expect to cover the entire subject. I shall touch on progress being made in the production of better soybean oil and in the development of high-protein food products from soybeans. Naturally, in my discussion I shall draw heavily upon the work being done at USDA's Northern Regional Research Laboratory in Peoria, Ill.

This has been a big year for soybeans. Yet, in some respects it has been a rather disappointing one. The predicted one billion bushel crop did not materialize because of some unfavorable weather. Nevertheless, the crop did not fall too far short of the mark. Indeed, we have seen a continuation of the dramatic increase in production and use of soybeans. In this respect, the year has added another chapter to the amazing story of a new giant in American agriculture.

A few words about the history of soybeans will remind us of how far we have come. Apparently, soybeans originated in the Orient. Records indicate they were being grown in China at least five thousand years ago. Since then they have become important in the Far East as a food, particularly in supplying protein.

In the United States, by comparison, soybeans are something of a "new born babe." Yet, this infant has become a giant in only a few decades. Soybeans became of truly commercial interest as a crop in the United States in the 1920's and early 1930's. In the remarkably short period of some 40 years, soybeans have increased in importance to such an extent that in 1967 they were proclaimed to be the No. 1 cash crop for the farmers of the United States. We know now that this claim may have been a little premature. Revised estimates for sales in the year ending in July 1967 left corn slightly ahead of soybeans in terms of actual cash received by the farmer. The difference, however, was less than one-half of 1 percent.

The world-wide significance of the United States crop of soybeans becomes apparent when we consider that we produce more than 70 percent of the world's total. Mainland China now produces only about 20 percent of the total world supply. It seems almost ironic that one of our major export markets is Japan. We are sending soybeans back to the Orient—where they originated.

Within the United States the Corn Belt really has become the Corn-Soy Belt, accounting for some 55 percent of total domestic production of soybeans. The South soon will catch up. This past year Southern States produced around 30 percent of the U.S. total. The Delta States alone accounted for around 20 percent. In fact, a recent issue of the Soybean Digest contained a short item with the heading "Soybeans Now King of the South."

With this background of the overall importance of soybeans, let us look now at what is done with these increasing amounts of soybeans. The disposition of soybeans during the past 10 years is shown in figure 1. The total each year reflects the rather rapid increase in amount of soybeans being produced and used. The main outlet, of course, is crushing for soybean oil. Exports have taken an increasing proportion of the total crop. The rest has gone to seed and direct feed use. In this category also is included the so-called loss, reflecting the difference resulting from statistical collection of information.

Relative to processing, essentially all crushing of soybeans for oil in the United States is done by solvent-extraction procedures. Almost no screw-pressing exists any more.

What is done with the soybean oil? Figure 2 shows the disposition of oil in 1966-67. For this figure we have left out the oil equivalent of soybeans that are exported, although in some reports these are included in the total.

By far the largest portion (73 percent) of the oil was processed for food uses. These include: margarine (22 percent), shortening (29 percent), and cooking and salad oils (22 percent). Exports accounted for 19 percent of the oil, whereas nonfood uses accounted for 8 percent.

Among food uses, margarine was the first to gain major importance. The actual amount of oil consumed for margarine increased for a number of years and then leveled off at around one billion pounds annually.

Use of soybean oil in the production of shortening experienced a fairly sharp rise during the past 10 to 15 years. The amount going into shortening may now be approaching a plateau.

Production of salad and cooking oils from soybeans has increased most markedly only during the past 5 years. The delay in entering this market reflects a problem which soybean oil has had to face; namely, the problem of flavor or flavor stability. At the same time, the increasing quantity of soybean oil for salad and cooking oils reflects progress through research toward solving this problem.

Research on soybean oil flavor has

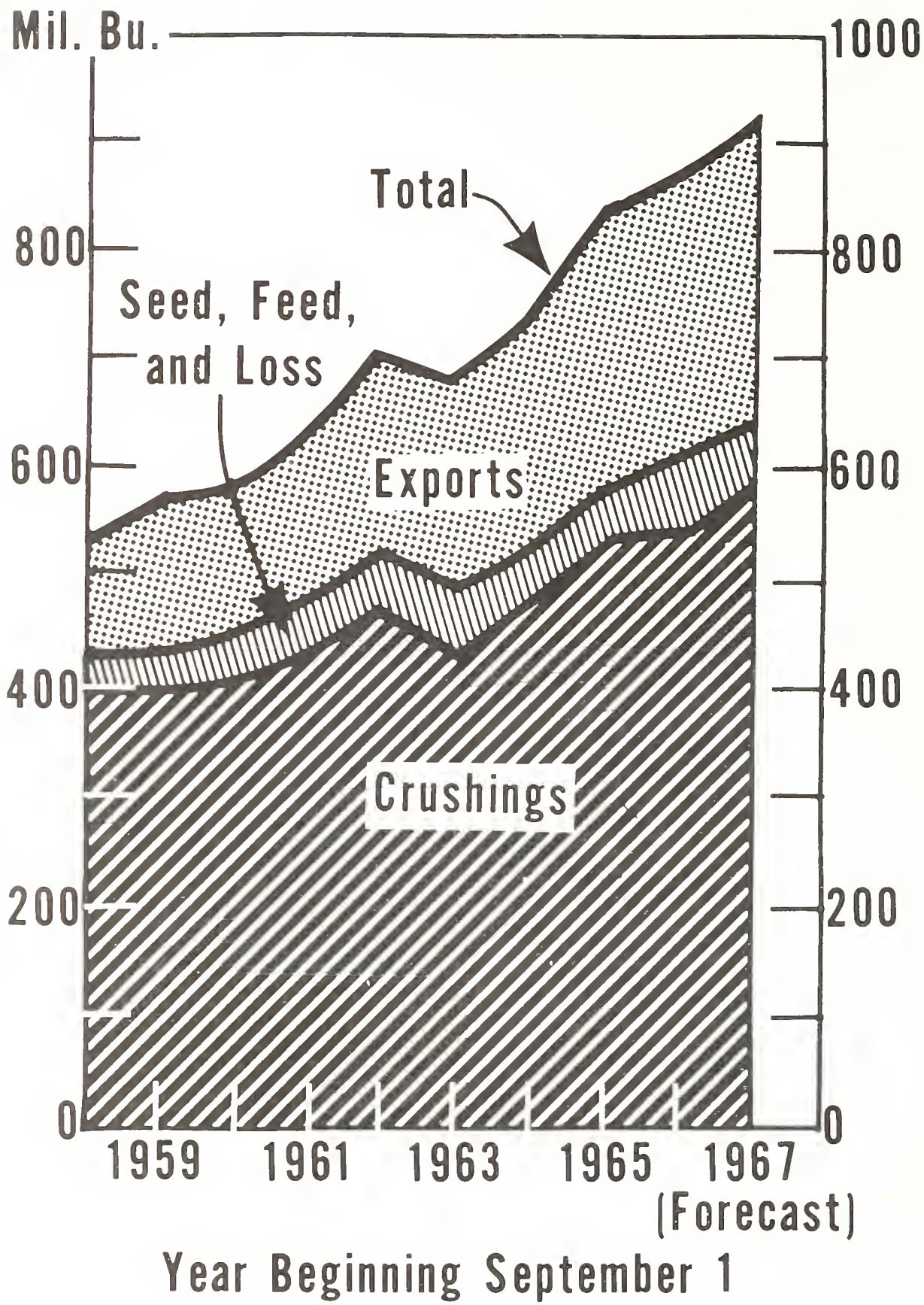

Figure 1. Disposition of soybean crop for the past 10 years.

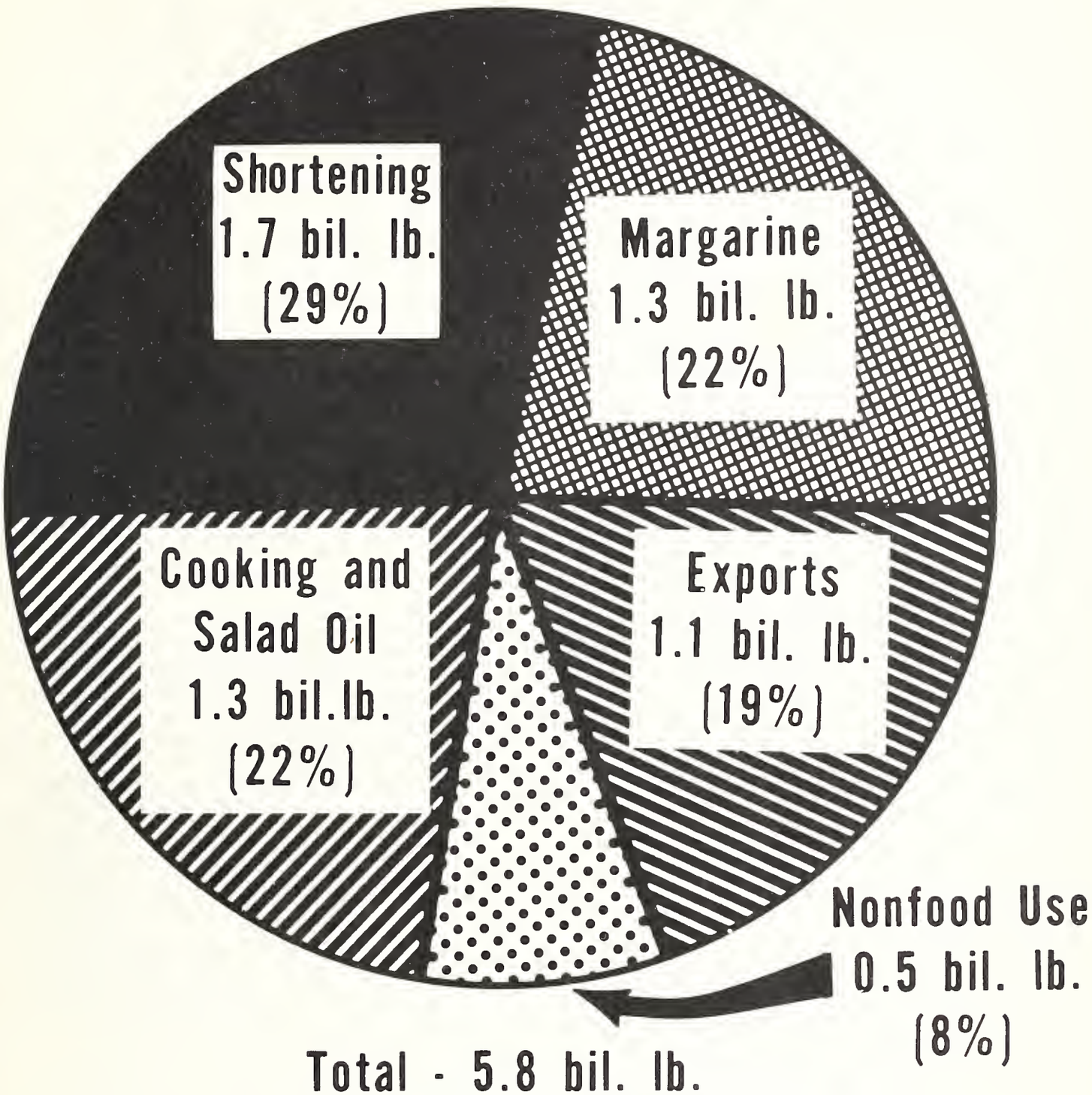

Figure 2. Disposition of U.S. soybean oil, 1966–67 (preliminary).

been an important part of the program at the Northern Regional Research Laboratory. We have directed our attention to methods of measuring flavor, change, reasons for the changes, and methods for minimizing or preventing them.

The measurement of flavor change still depends on the human tongue, despite the many advances in analytical instrumentation. Early in our research program, we set up a taste panel with carefully controlled conditions for doing the tasting. A special room was set aside for this purpose with isolation booths to prevent the activities and facial expressions of the neighboring taster from influencing judgment. We also have red light as well as white so that differences in color of samples can be hidden. Fresh air and temperature control of both the air and the samples are further features. in the operation of our taste panel. Finally, the members of the panel have been selected from our staff on the basis of their ability to detect small changes in soybean oil flavor. Not all people have equal sensitivity to specific flavors. Only by such precautions can one get the maximum amount of meaningful information on the flavor stability of the oil and the effects of treatments on that stability.

In seeking causes for changes in flavor, we found that metal salts were particularly important. Some indications of the effect of traces of iron and copper on the flavor score are shown in table 1. As little as 0.3 parts per million of iron salts cause a noticcable drop in the initial flavor score and a further drop on aging. An increase of the iron content to 1.0 parts per million causes a still greater loss of good flavor or development of off-flavor. Similarly, very small amounts of copper (0.3 parts per million) bring about a dramatic drop in flavor score, particularly after the oil was aged for 4 days at 140° F.

Table 1.—Effect of iron and copper on stability of soybean oil.

Metal added	Flavor score	
	Initial oil	Aged oil 1/
None	8.1	7.1
Iron, 0.3 p.p.m.	6.1	5.9
Iron, 1.0 p.p.m.	4.6	3.4
Copper, 0.3 p.p.m.	6.5	2.2

1/ 4 days at 60° C. (140° F.)

Metal salts are not the only factor involved in flavor changes. Air or oxygen also is needed. In fact, the metal acts as a catalyst to promote oxidative

changes in the soybean oil. When the oil is kept under nitrogen, changes in flavor are much less.

The bad effect of metal salts can be prevented, at least to a considerable extent, by adding citric acid to the oil. The effectiveness of citric acid is shown by the data in table 2. The addition of citric acid almost completely overcomes

Table 2.—Effect of citric acid on soybean oil containing iron.

Treatment	Flavor score	
	Initial oil	Aged oil 1/
None	8.1	6.9
Iron, 1.0 p.p.m.	4.6	3.1
Citric and 1 p.p.m. iron	7.8	5.9

1/ 4 days at 60° C. (140° F.) open to air.

the effect of 1 part per million of iron on the initial flavor score. Furthermore, it greatly retards the drop in flavor score on aging of the oil.

Citric acid had been used commercially as a means of improving soybean oil before we did these studies. However, it was not fully recognized why citric acid improved flavor stability. Our demonstration of the relationship between metal ions, oxygen, and citric acid gave a better understanding of what was going on and provided a better basis for controlling the citric acid treatment.

In view of the importance of metal ions and oxygen, we can pinpoint factors that need to be watched in processing soybean oil. Metal contamination must be avoided or minimized. For example, a brass valve in a processing line can introduce undesirable quantities of copper into the oil, thereby lowering the flavor stability. Another important feature is protection against oxidative changes. For this purpose an appropriate precaution is avoiding any contact of the oil with air or oxygen during processing, especially when the oil is at high temperature.

Why is soybean oil sensitive to these oxidative changes in flavor? In fact, why is cottonseed oil so much more stable in this respect? To answer these questions we must take a quick look at a little of the chemistry of soybean oil.

Three different unsaturated fatty acids are present in soybean oil. Two of these also are in cottonseed oil and in about the same amounts. These are oleic acid and one double bond and linoleic acid with two double bonds. They make up respectively, about 22 percent and 55 percent of the total

fatty acids in soybean oil. The third component, which is absent from cottonseed oil, is linoleic acid with three double bonds. This triply unsaturated fatty acid apparently is the main culprit in the change of flavor of soybean oil in the presence of oxygen and metal salts.

Obviously, the best way to stabilize the flavor of soybean oil is to completely eliminate linoleic acid from the picture. Two approaches merit consideration. One is through genetics, with the objective of breeding a linolenic acid-free soybean. The other approach, with which we are concerned right now at the Northern Laboratory, is to selectively remove linolenic acid by hydrogenation.

Ideally, the objective of selective hydrogenation of soybean oil is to reduce one double bond of linolenic acid and produce a doubly unsaturated fatty acid. At the same time there could be no change in the other double bonds of linolenic acid or those of the other unsaturated fatty acids. Particularly important is to avoid reduction of the single double bond in oleic acid to produce fully saturated fatty acid. The saturated fats are solid rather than liquid so that selectivity in hydrogenation is necessary to retain the liquid character of the oil.

Considerable progress in selective hydrogenation has been made in our research (figure 3). Here an ordinary commercial hydrogenation catalyst is compared with a much more selective catalyst in terms of the amount of the undesired triply unsaturated linolenic acid and the combined amounts of doubly unsaturated linoleic acid and singly unsaturated oleic acid, both of which are desirable components.

The original oil contained about 7 percent linolenic acid and 79 percent of the other unsaturated fatty acids. Limited reduction with a nickel catalyst lowered the linolenic acid to 4 percent but, at the same time, decreased the amount of other unsaturated fatty acids. Even at this stage of hydrogenation, there is an undesirable change of unsaturated fatty acids to fully saturated ones.

Some of the newer catalysts, which we have been studying experimentally, give oil having only 2 percent or less of linolenic acid, while at the same time the amount of the other unsaturated fatty acids is increased rather than decreased. This increase indicates that we are indeed reducing the triply unsaturated linolenic acid to doubly or singly unsaturated fatty acids without any significant reduction of these to fully saturated acids.

The importance of this selectivity is in retention of the liquid character of the oil as indicated before. Despite their lack of selectivity, conventional catalysts have been used to hydrogenate soybean oil partially to improve flavor stability. However, a winterization step is required in order to remove at least part of the increased amount of wholly saturated fatty acids. This step is necessary to give an oil that will not become cloudy on refrigeration. The hydrogenation-winterization process has a disadvantage from the practical viewpoint of involving the separation of a considerable percentage of solid fat, which has less value than the oil.

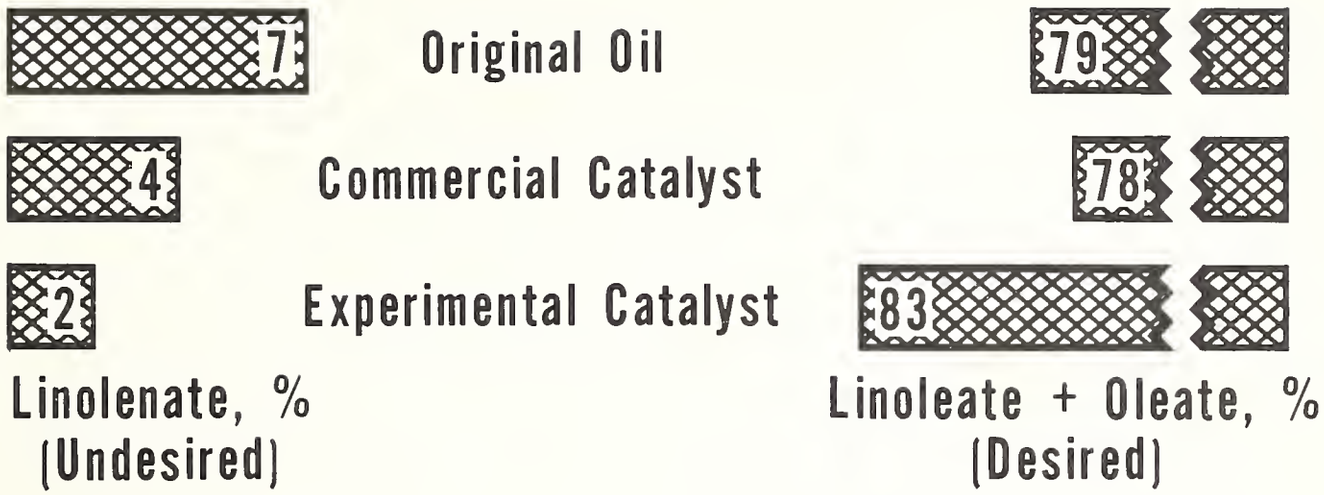

Figure 3. Soybean oil improved for world markets.

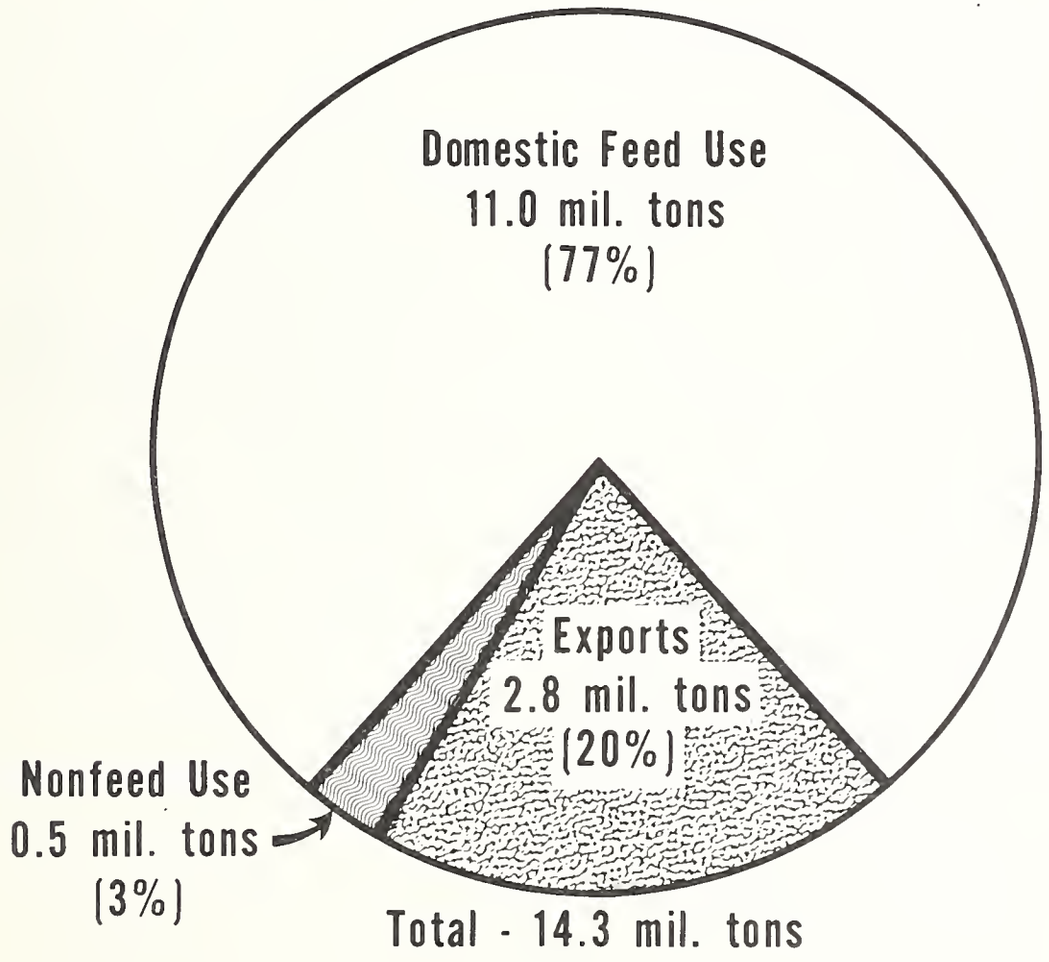

Figure 4. Disposition of U.S. Soybean meal, 1967 – 68 (forecast).

Selective catalysts for hydrogenation allows one to reach a lower linolenic acid content than with conventional catalysts, while at the same time requiring either no winterization or only a relatively small winterization loss of material.

Research on the selective hydrogenation of soybean oil is continuing. There are still problems to be solved. The selective catalysts we have used so far contain copper. Their use imparts an undesirably high level of copper to the hydrogenated oil. Therefore, we are working on methods to remove the copper. We then will be able to determine whether the flavor stability of the oil has been improved as anticipated.

Let us turn now from the oil to the rest of the soybean; namely, the soybean meal. The outlets for soybean meal forecast for 1967-68 are seen in figure 4. Domestic feed use takes by far the greatest proportion of the meal, accounting for about 77 percent. Next in importance is export trade, accounting for about 20 percent of the meal. Nonfeed uses, 3 percent, include both industrial products and food products. While food uses of soybean meal are relatively small at present, we can expect considerable increases in the future.

Food uses of soybean meal, or fractions thereof, generally are based on the high level of protein present. The several different forms of soybean protein available commercially for food use cover a considerable range of protein content, from about 40 percent to nearly 100 percent.

Full-fat soy flour with about 40 percent protein is the simplest processed form of a soybean protein food product. It contains essentially all the bean except the hull. Next in protein content is defatted soy flour with 50 percent protein. Finally, protein concentrates (about 70 percent protein) and isolated protein (around 95 percent protein) are products obtained by further processing of soybean meal. These last two forms of soy protein are the ones from which industrial research is developing exciting new forms of food products, such as simulated meats.

In the production and handling of soybean meal for food use, the initial processing is a very important matter. A moist heat treatment, called toasting, generally is used to improve nutritive value of the meal. Heating must be carefully controlled to avoid unnecessary loss of functional properties of the meal or protein. The effect of heating on nutritive value is demonstrated by the data on rat feeding in table 3. The weight gain of rats on different diets is shown, along with the food efficiency which gives a better basis for comparison since it minimizes individual differences of the animals. For these studies casein is used as a reference protein. This choice does not mean that casein is an ideal protein, although it is relatively good nutritionally. More important, it can be obtained readily in uniform quality for feeding studies.

With raw soybean meal as the source of protein, weight gain of the rats was much lower and feed efficiency was down almost to half of that for casein. The marked improvement in the soybean meal upon moist heat treatment is apparent in both the weight gain and the protein efficiency. Treated meal is com-

Table 3.—Effects of raw and heated soybean meal on growth of rats.

Dietary protein	Final body weight	Food efficieney,
	Gram	Weight gain per gram of food
Casein	147	0.31
Raw soybean meal	89	.19
Heated soybean meal	148	.29

parable to casein in feeding quality.

The improvement in soybean meal on heat treatment is a result from the destruction of antinutritional factors. One of these is trypsin inhibitor. We have observed a good parallel between the increase in protein efficiency ratio and the decrease in trypsin inhibitor. Destruction of urease activity provides a useful guide to the progress of heat treatment because it is easily measured.

Heat treatment of soybean meal, however, must not be overdone. Moist heat causes some progressive changes in soybean protein. These include denaturation and loss of some of the functional properties important for a number of purposes. Therefore, for some products one may even have to limit the heat treatment to incomplete destruction of urease or trypsin inhibitor. Of course, destruction is completed later if the final food product is cooked during processing or preparation.

Steaming or moist heat not only improves nutritional quality of the meal but also improves its flavor. Raw soybeans or untreated soybean meal has a strong beany flavor. Steaming progressively removes much of the raw flavor, leaving a milder somewhat nutty flavor. For some food uses, the flavor of soybean products still is a problem. We and other research groups are continuing research to find out more about the chemistry of the flavor and how to remove or destroy it.

Continuing with the thought of increased use of soybeans in foods, one might ask what the virtue is of soybeans as a source of protein. Actually, the virtue of soybeans in human foods is the same as in the well-established use of soybean meal in mixed feeds for animals. The soybean supplies a good quality protein at low cost. Even more important, the proteins of soybeans and cereal grains complement each other in terms of the nutritionally essential amino acids. Since the diets of many people throughout the world naturally have high levels of cereal grain foods, obvious opportunities exist for using soybeans to improve the protein content and nutritional value of such diets.

Progress in this use of soybeans has been particularly noteworthy under the Food for Freedom program. The mixture known as CSM combines pro-

cessed cornmeal, toasted (moist heat treatment) soy flour, and nonfat dry milk solids with vitamins and minerals to provide a high-protein food supplement. The United States Government has purchased this mixture under the specifications for Blended Food Product, Formula No. 2. The original formula consisted of: gelatinized cornmeal, 68 percent by weight; defatted soy flour which has been adequately toasted, 25 percent; nonfat dry milk solids, 5 percent; and a vitamin-mineral premix, 2 percent. The entire blend has a minimum protein content of 19 percent on a dry basis and an adjusted fat content of at least 2 percent. More recently, the specifications have been revised to provide a higher fat content of at least 6 percent.

CSM is intended primarily for a gruel in the feeding of preschool children. It can, of course, be used in other ways. As part of the Food for Freedom program, the distribution of CSM contributes to the improvement of nutrition in the developing countries. Since it is to be used as a food supplement rather than the entire meal, the use of CSM is introducing into the protein-hungry countries the concepts of supplementary feeding and formulated foods which we have come to take for granted. I am sure that CSM also will extend the acceptance of soybeans as a component of foods.

Considerable study was required for the development of CSM and the specifications under which it is purchased. The composition of CSM was established through cooperation and discussions between members of the U.S. Department of Agriculture, the National Institutes of Health, and the Agency for International Development. A leadership role in the preparation of products and early testing of acceptability of CSM was taken by the American Corn Millers Federation. Our staff at the Northern Laboratory has been particularly concerned with methods for measuring and controlling properties of the ingredients, evaluating stability of CSM on storage, investigating alternative methods for processing the cornmeal and soy flour, and evaluating to a limited extent alternative ingredients.

Purchases of CSM by the Government started in the fall of 1966. By the beginning of 1968, about 300 million pounds had been purchased, representing over a million bushels of soybeans. CSM is packaged in 50-pound milti-wall bags, and distributed under the Food for Freedom program by such voluntary agencies as Care, Church World Service, and Catholic Relief.

Purchase and distribution of CSM are expected to continue and perhaps increase. At the same time, consideration is being given to other formulations, such as a combination of wheat with soy flour or soybean flakes. Through these activities, I am sure that we will see a number of developments in the use of soy flour as a constituent of high-protein formulated foods or food supplements.

Let us return now to the soybean itself as a food material. Full-fat soy flour is one form in which the entire bean, except for the hull, can be used as a food product. The Agency for International Development asked the Northern Laboratory to work out simple processes for making full-fat soy flour for use in the developing countries.

With support from A I D we have worked out two processes: One, the Village Process with hand-operated equipment; the other, an extrusion-cooking process for larger scale operation.

A flow diagram for the Village Process is shown in figure 5. Whole soybeans first are soaked in water for several hours so that they will cook more rapidly. After being drained, the soaked beans are cooked 10 to 15 minutes in boiling water. The cooking step has three benefits. First, the inactivation of enzymes, such as lipoxidases and lipases, which otherwise would make the final flour unstable in terms of flavor changes on storage. Second, the improvement of flavor, particularly destruction of most of the raw beany flavor. Third, the destruction of factors that would lower the nutritional quality of the product. The use of boiling water gives easy control of temperature while there is reasonable leeway in timing of the cooking. The cooked beans are air-dried, preferably in the sunshine. At this point, the hulls have been somewhat loosened so that when the beans are put through a coarse grinding or cracking, the hulls are freed from the pieces of bean. The hulls then are removed by aspiration in a hand-operated winnowing machine. The clean meats or grits resulting are then ground to flour. This Village Process is being put into operation in Brazil using equipment purchased by UNICEF.

The extrusion cooking process, for which the flow diagram is shown in figure 6, we also developed but for larger scale operation. An important feature of this process is the speed of processing. The tempered grits or flakes are preheated before going into the extrusion cooking equipment. During extrusion, a further rapid rise in temperature occurs. As a result, enzymes are quickly destroyed before they can have an undesirable action on the oil. The resulting full-fat soy flour, therefore, has very good storage stability as does the flour from the Village Process.

Full-fat soy flour can be used to increase the protein content of a number of foods. In addition, it can be used in beverage form. Retention of the oil in the full-fat soy flour offers the advantage of providing calories along with a high-quality protein.

I trust that this review of progress on soybean oil and high-protein soybean products gives some indication of the increasing importance of soybeans in food uses. With further research and development, we can be sure that soybeans will continue to have a great future.

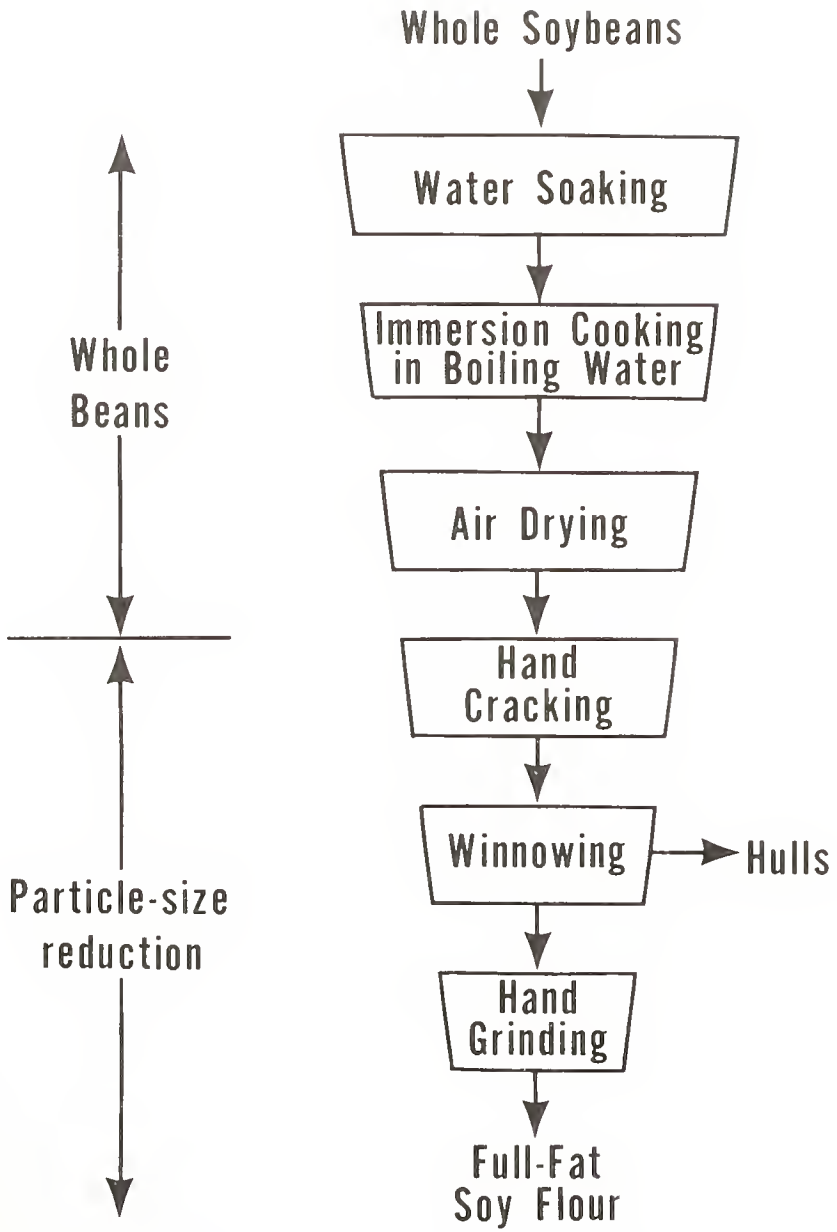

Figure 5. Flow diagram for the Village Process for full-fat soy flour.

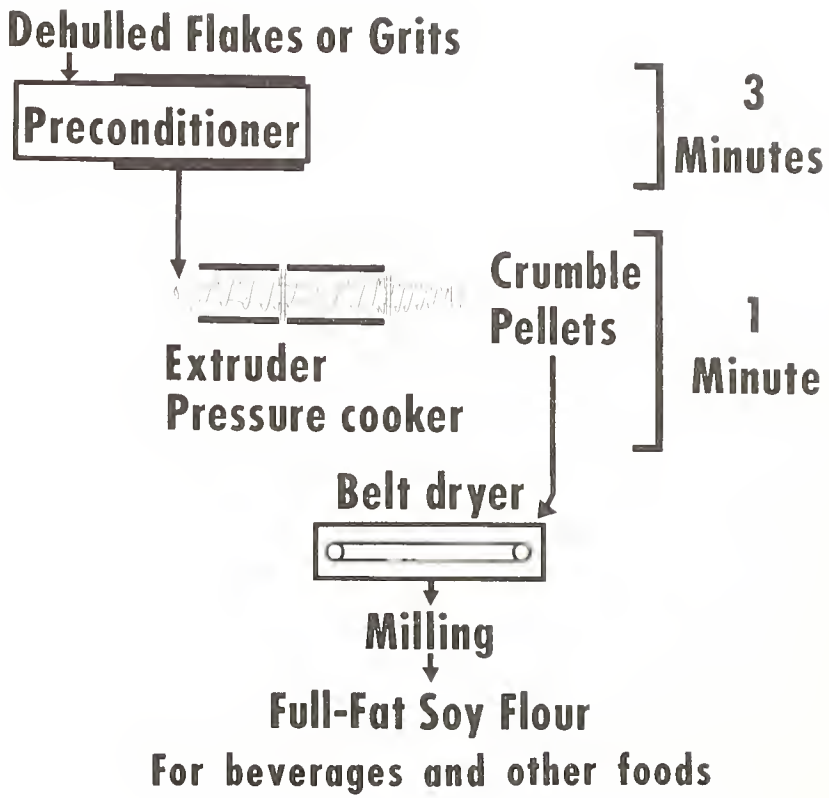

Figure 6. Rapid extrusion–cooking process for full-fat soy flour for use in developing countries.

SESSION III: N. P. Bartmess, Kennett Oil Mill, Inc., Chairman

AMINO ACID SUPPLEMENTATION OF COTTONSEED MEAL

by
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Agricultural Experiment Station
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In any discussion of amino acid supplementation of cottonseed meal, one must consider the factors involved in protein quality and factors affecting this. Protein quality may be said to be the overall effect of the following four factors:

(1) Amount of amino acids in protein

(2) Availability of amino acids

(3) Amino acid balance

(4) Presence of interfering materials.

Cottonseed meal is deficient in five essential amino acids, thus it is not a complete protein. If only cottonseed meal protein is used, it must be supplemented with lysine, methionine, leucine, threonine, and isoleucine. However, very few proteins are complete. Soybean meal, for example, is deficient in lysine and methionine.

In the matter of availability of amino acids, cottonseed meal has more problems than soybean meal. Generally mild heat treatment makes proteins more digestible. However, with cottonseed meal heating in the presence of gossypol reduces the availability of amino acids, particularly lysine. In addition, gossypol in the rations above certain levels is toxic and reduces growth.

There is no indication that cottonseed meal rations suffer from amino acid imbalances so this factor appears to be of little consequence. The effect of gossypol has already been mentioned.

In properly evaluating a protein for a ration, the contribution of amino acids of the materials other than the protein of the supplement must be considered. About two-thirds of a poultry ration is made up of cereal grains of which corn is the standard. Protein supplements make up about 30 percent of the ration and the rest are mineral and vitamin supplements.

If one considers only the contribution of cottonseed meal to the ration, the ration would be deficient in lysine, methionine, threonine, leucine, and isoleucine. A ration containing 30 percent cottonseed meal would contribute the following percentages of the requirement of these amino acids to the ration—77 percent lysine, 46 percent methionine, 67 percent threonine, 73 percent leucine, and 85 percent isoleucine. However, on the same basis soybean meal would contribute, 88, 46, 80, 100, and 113 percent, respectively. Neither would be adequate alone.

As mentioned earlier, corn contributes some protein to the ration. This amounts to 8 percent of the lysine re-

quirement, 32 percent of the methionine, 43 percent of the threonine, 37 percent of the leucine and 15 percent of the isoleucine. When these contributions are added to those of the cottonseed meal, the only ones lacking are lysine and methionine. The addition of 3 percent fish meal to the ration supplies these amino acids. It should be pointed out that soybean meal also would be lacking in these same two amino acids. It should also be realized that, at present prices, it costs about $3.60 per ton to add these amino acids in the form of fishmeal. Both methionine and lysine are available commercially and can be added for about the same costs.

From a protein standpoint, cottonseed meal can be used successfully in poultry rations. The primary deterrant to its use at the present time is the presence of gossypol. Gossypol, in addition to being toxic, combines with lysine and other amino acids to make these less available. The most pressing limitation at the present time is the danger of using cottonseed meals in laying rations as the gossypol causes discolored yolks in the eggs. In rations for poultry, other than layers, there should be no hesitance to using cottonseed meals with high nitrogen solubility and low free gossypol.

DISCUSSION

Question: I would like to know where you are buying your soybean and cottonseed meal at $100 a ton.

Dr. Watts: We make all of our feed from the ground up on our research farm. We use a 23-ton truck about every 5 or 6 weeks. We get it, in 100-pound bags trucked in from northern Arkansas and Memphis. I bought up a 23-ton car yesterday at $103.50 a ton—sacked hundreds—delivered in our feed rooms. That is the cheapest it has been in a year.

Question: This cottonseed meal, is that a low fiber, high-protein meal?

Dr. Watts: Fiber is imported only insofar as it has enough protein to be able to balance the ration satisfactory. At the present time we have to have about 44 percent protein in a supplement to be able to do this. We have so much else to put in that if we put in 41 percent cottonseed meal, we have to use some of this 7.5-cents-per-pound tallow to boost the energy and this is too expensive. Fiber is of no consequence as far as the protein supplement is concerned, but it does dilute the protein concentrate.

Question: Do you think there is a temperature where more of the lysine would become available in the cottonsced meal?

Dr. Watts: There is no question about it in the work we have done. The three meals we had in that digestibility slide were picked upon the temperature in which they were processed. Somewhere from 190 to 220 gave us the best lysine availability. That meal not only had 45 percent lysine availability, but it had lower lysine to start with. There had been a loss of lysine when the heating was up around 260, 265, and 285. Yes, temperature is very important, but it is not peculiar to cottonseed at all. It can be demonstrated with other proteins. The problem here is gossypol which complicates the problem also.

THE FEDERAL GOVERNMENT'S ROLE IN WATER POLLUTION CONTROL

by
J. R. Thoman
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U. S. Department of the Interior

(Presented by John C. White)

(No copy of this paper available for publication.)

THE FEDERAL ROLE IN AIR POLLUTION CONTROL

by
G. B. Welsh
National Center for Air Pollution Control
U. S. Public Health Service

It is indeed a pleasure to participate in this the Seventeenth Cottonseed Processing Clinic. The opportunity is especially welcome at this time because a few weeks ago President Johnson signed into law the Air Quality Act of 1967. This law will greatly expand the battle against air pollution at every level of Government.

Today this Nation is engaged in a conflict against a growing combination of threats to the environment on which we must depend for life. Of all these threats, air pollution is potentially the most deadly; certainly it is one of the most difficult to solve. We live in an age when all of the elements supporting life have been severely damaged—our land, our water, and the air we breathe. In finding our way back there is one major difference—we can purify the water before we drink it; we can restore the scarred and lacerated land; but, we must use the air as it comes to us, polluted or otherwise.

Air pollution is not new. Some air pollution such as smoke and fly ash from forest fires, smoke and gases from volcanic activity, pollen and others have existed from the beginning of time. Man-made air pollution has probably existed since the time fire was first used for beneficial purposes. In the year 1273, the first smoke control law was passed in England. Industrial developments in the United States during the late 1800's led to the enactment of the first smoke control law in Chicago in 1881 followed by St. Louis, Pittsburgh, and others. In the late 1940's, a new type of air pollution became very apparent in Los Angeles. This was an entirely different type of air pollution problem. It did not have the great quantities of smoke, dust, and dirt that was typieal of other cities, but it did have an effect on the eyes, nose, and throat. Sometime later, it was clearly established that this type of air pollution problem was primarily due to an atmosphere reaction of unburned gasoline and other air pollutants that were very prevalent in

the Los Angeles area. This type of air pollution problem is now referred to as photochemical smog and it occurs in many of our metropolitan areas.

Air pollution has many adverse effects on the community, such as nuisances, reduced visibility, reduced property values, damage to property, livestock, and vegetation. Economic loss resulting from present-day air pollution takes many forms including soiling, corrosion, deterioration of buildings and other structures, added expenses for cleaning of household goods, maintenance of property, wasted fuel, and depressed real estate values. Estimates of these losses nationally place the total as high as $11 billion annually or about 60 dollars per person per year. That is indeed a high price to pay when you consider that it is largely unnecessary. The knowledge and equipment are available to control most major sources of air pollution.

In addition to the economic effects, air pollution has an effect on the public health and welfare. The Donora episode of 1948, the London episodes of 1952 and 1962, and the New York City episodes of 1953 and 1966 are all examples. These episodes have shown that high air pollution concentrations over a period of a few days can cause death. We are even more concerned about the health hazards associated with the long-term daily exposure of millions of our urban dwellers to lower levels of air pollution. This problem has been the subject of many different types of studies. The results of these studies indicate that air pollution is associated with the occurrence and worsening of many serious respiratory diseases, including asthma, chronic bronchitis, lung cancer, and emphysema. Some of these diseases are causing increased sickness, disability, and death with every passing year. There are still gaps in our knowledge about the relationship between air pollution and the occurrence of respiratory diseases. Even so, the evidence already on hand demonstrates beyond doubt that air pollution is a hazard to our public health and welfare.

The Air Quality Act of 1967 authorizes more Federal funds to combat air pollution than we have spent in all 180 years of our history. The need for action on this scale was never more clearly spelled out than in the President's remarks at the ceremonies attending the signing of the bill.

"We are pouring at least 130 million tons of poison into the air each year." the President said. "This is two-thirds of a ton for every man, woman, and child in America. And tomorrow looks even blacker. By 1980, we will have a third more people in our cities; we will have 40 percent more automobiles and trucks; and we will be burning half again as much fuel. That leaves us only one choice. Either we stop poisoning our air, or we become a nation in gas masks, groping our way through dying cities and a wilderness of ghost towns."

The President added: "This new Air Quality Act lets us face up to our problem as never before...it will help our States fight pollution in the only practical way—by regional 'airshed' controls—by giving the Federal Government standby powers to intervene if States fail to act.... Let us seize the new powers of this new law to end a long,

dark night of neglect. Let our children say, when they look back on this day, that it was here a nation awokc."

Now, of course, this is not to say that we have been totally asleep prior to this action. The first identifiable Federal air pollution program was established in 1955. This program authorized the Public Health Service to aid State and local air pollution programs by conducting research and providing teehnical assistance. The continued growth of the air pollution problem nationally, coupled with the improved documentation of its effects on public health and welfare, made it clear that State and local air pollution control efforts, evcn when backed by Federal research and technical assistanee, were not adequate to cope with the challenge posed by the air pollution problem.

Recognition of this fact was reflected in the development and passage of the Clean Air Aet in 1963 and subsequent amendments in 1965, 1966, and 1967. This marked an important shift in the national policy and added new dimensions to the Federal program. This approaeh reeognized that a eombination of aetivities by the local, State, and Federal governments was necessary to eontrol air pollution. The first Federal air pollution legislation in 1955 specifiед that the prevention and control of air pollution at its source was the primary responsibility of the State and loeal governments. The Clean Air Act of 1963 and the subsequent amendments have reaffirmed this poliey.

The Federal government air pollution program has been designed primarily to assist the State and loeal governments in meeting their responsibilities for the prevention and control of air pollution. In this role, the Federal program activities include: (1) Research, (2) technical assistance, (3) financial assistance, (4) abatement, and (5) development and publication of air quality criteria and control technology data.

The research activities of the Federal program covers a number of fields and applications which ineludes: Medical and biological laboratory research dealing with plants, animals, and man; field studies to investigate the effects of air pollution on man and property; engineering aspects of air pollution and its control; and the chemical, physical, and meteorological aspeets of air pollution. Air quality measurements are also eonsidered a part of the research activities because the data is nccessary to evaluate the seasonal and geographic trends of various air pollutants. Research is needed to improve our technieal knowlcdge on the air pollution problem and how it can be solved.

Technical assistance is an important function of the Federal air pollution program. This activity is primarily aimed at the translation of all types of air pollution information into effective air resource management programs which will restore or maintain acceptable air quality throughout the Nation. Technical assistance is provided to State and local air pollution control agencies for the planning, organization, development, and operation of air pollution control programs; specialized training of personnel to implement or improve the State and local control programs; and the development and implementation of long-range air use plans. Specialized

technical training courses of one or two weeks' duration are provided in Cincinnati or at certain field locations and this is considered an important type of technical assistance. As an example, each fiscal year about 25 different training courses are presented, representing approximately 45 weeks of instruction, with an attendance of more than 1,100 students. In addition, the Federal program supports graduate level training in air pollution for about 125 students per year through training grants and special fellowships.

A program to provide financial assistance to State and local air pollution control agencies in the form of matching grants was authorized with the enactment of the Clean Air Act of 1963. The purpose of these matching grants is to develop, establish, improve, or maintain State and local air pollution control programs. During the past 3 years, through the matching grants provision of the Clean Air Act, State and local air pollution control programs have been able to increase their budgets from less than $13 million before passage of the Clean Air Act, to approximately $26 million during the current year. The number of States with legal authority to control air pollution has now reached 38 as compared to 16 before 1963. At the local level, nearly 100 programs are now in operation, while another 30 to 40 are in various stages of development; both of these figures reflect appreciable progress.

Major activities of the Federal abatement effort are aimed at the following: (1) Air pollution problems that are interstate or international in scope (although procedures for involvement of the Federal government in intrastate problems are also included in the legislation); (2) the establishment of standards for controlling air pollution emissions from new motor vehicles; and (3) the setting of standards for controlling air pollution emissions from Federal installations. The law provides specific procedures for the abatement of interstate air pollution problems: in brief, the steps are: (1) Consultation, (2) conference, (3) hearing, and (4) court action. Specified time limits are allowed for corrective action between each of the last three steps of the procedure. So far, nine interstate and one intrastate abatement conferences have been held. Under the authority of the Clean Air Act, Federal standards for the control of air pollution emissions from motor vehicles were published in March 1966. These standards limit the carbon monoxide and hydrocarbon emissions from new gasoline powered motor vehicles beginning with the 1968 models, both American made and foreign imports. These standards will require a significant reduction in the motor vehicle exhaust emissions. Under the more stringent standards recently proposed, the motor vehicles will be required to make further reductions in their air pollution emissions beginning with the 1970 models. Another area of actual Federal control of air pollution is related to the Federal installations. On May 26, 1966, an Executive Order was issued that requires all Federal agencies to take steps to prevent and control air pollution from Federal installations. It also authorized the Secretary of Health, Education, and Welfare to prescribe standards to implement the objectives of the Executive Order. Pursuant to the Executive Order, on June 3 specific stan-

dards were published for the prevention and control of air pollution from Federal installations. These standards provide detailed and specific guidelines for the Federal agencies to prevent and control air pollution from their respective facilities.

From this, it is evident that we have made some progress toward solving our National air pollution problems during the past 4 years under the Clean Air Act and the subsequent amendments. We have, for example, through the approaches of interstate air pollution problems, standards for motor vehicles, standards for Federal installations, the development of State and local air pollution control programs, and additional research, taken actions which will ultimately benefit millions of people. The progress we have made thus far—when weighed against the vast and complicated problem confronting us—represents little more than "baby steps."

Quite clearly, the Nation has failed, thus far, to come to grips with many of the most complex and difficult aspects of the air pollution problem. There are still many important sources of pollution which we know how to control, but which nonetheless remain uncontrolled. There are still many other important sources of air pollution for which practical and effective control technology is not available. There are still very few places where emission standards have been established to indicate the extent to which industries must control their air pollution problems. There are still no effective programs in operation to deal with interstate air pollution problems on a regional basis.

With the passage of the Air Quality Act of 1967, the Nation is moving into a new era in the control of air pollution. The new legislation establishes an entirely different and, to my mind, a far more practical and workable relationship between the States and the Federal Government in which our interdependence, based on statutory requirements for interrelated action, will become more clearly apparent than ever before. Just how fast we progress in this new era will depend heavily on how vigorously we all pursue our respective responsibilities.

Under the Air Quality Act of 1967, the first responsibility assigned to the Department of Health, Education, and Welfare is that of delineating the broad atmospheric areas of the Nation—mainly on the basis of those meteorological and topographic factors that influence the diffusion and transport of pollutants in the air. On January 16, 1968, the eight atmospheric areas were defined and now the Department is empowered to designate air quality control regions throughout the Nation. These regions can include parts of two or more States or can lie entirely within a single State; in either case, the region will include a group of communities affected by a common air pollution problem. Action taken toward establishment of an air quality control region will not become final without prior consultation between the Department and the State and local agencies directly involved. Air quality control regions will be designated on the basis of factors which suggests that a group of communities should be treated as a unit for the purpose of setting and implementing air quality standards. In brief, the designation of air quality con-

trol regions will depend on meteorological and other technical aspects of air pollution, as these relate to social and political factors.

A second major provision of the Air Quality Act calls for the Department to continue to develop and publish air quality criteria reflecting the best available scientific data on the adverse effects of individual pollutants and combinations of pollutants. At the same time, we are directed to develop and publish detailed information on techniques for preventing and controlling air pollution, including cost-effectiveness analyses of alternative methods.

Provided with this information, the States themselves then will take over the responsibility for developing air quality standards, and plans for implementing the standards in the designated air quality control regions. The proposed standards and implementation plans will be submitted to the Department for evaluation, with approval based on their consistency with applicable air quality criteria and recommendations on control technology. Following this step, the approved standards and plans would become effective in the air quality control region for which they were developed.

At that point, the States would be expected to begin enforcement of emission standards for the control of air pollution sources as provided in their implementation plans, and according to the time schedules for enforcement provided in those plans. Enforcement action would be taken at the Federal level only if air quality in a designated region falls below the air quality standards for the region, and if the State does not implement its plans for meeting the standards.

Finally, in this survey of the major provisions of the Air Quality Act, I believe that we can all find the basis for new confidence in eventual victory in the authorization in the Air Quality Act for a research and development program on a scope never before envisioned.

Under this Act, the Federal funds authorized for research and development are vastly expanded—with a total of $125 million earmarked for this purpose over the next 2 years. At the same time, the Act provides statutory authority to help finance cooperative industry-Government research and development projects to bring about new and improved control technology. Thus, with industry's cooperation, the $125 million Federal expenditure can be multiplied into the kind of massive application of money and talents and resources which has long been necessary to close the technological gaps which hinder our struggle to achieve effective controls nationally.

But for all it will do, the Air Quality Act of 1967 will not end air pollution. It gives us new opportunities and fresh hopes, but in signing it, President Johnson reminded us of this hard fact when he said: "It is a law—not a magic wand to wave and cleanse our skies. It is a law whose ultimate effectiveness rests with the people."

The need for action, mutual understanding, and cooperation in controlling air pollution has never been so great or so urgent as it is today. But mutual understanding and cooperation without real effort on the part of those who are understanding each other and cooperating

with each other has never accomplished anything. What we need more than mutual understanding and cooperation is strong effort by government at all levels—and by all of the private sector—to carry out the activities which are so clearly needed. We all have an extraordinary opportunity to take effective action to cleanse our skies and protect the very air we breathe.

DISCUSSION

Question: I noticed you were talking about the emission from automobiles. You limited that to gasoline. Are diesel engines covered?

Mr. Welsh: No, the present standards which we have on the books apply only to gasoline powered vehicles. The proposed standards I mentioned that will be applicable to the 1970 models will also apply to diesels. There are several reasons why the first standards did not apply to diesels: First, we have about 80 million gasoline powered motor vehicles and about nine or ten million diesels—a ratio of about 8 to 1. Second, the amount of fuel burned per year is even greater. There is much more gasoline burned than diesel. Third, the unburned gasoline is what is contributing to the photochemical problem in Los Angeles and everywhere else. The diesel really has two problems, smoke and odor, but is not contributing to this eye, nose, and throat irritation we are experiencing in the areas that have photochemical air pollution.

Question: I just assumed it all contributed.

Mr. Welsh: It does, but the gasoline engine is a very inefficient machine and it is the unburned gasoline that is going out the tailpipe that is giving us the photochemical air pollution problem.

PESTICIDE RESIDUES

by
K. J. Smith
National Cottonseed Products Association, Inc.

Before discussing the broad topic of "pesticide residues," I would like to review what is implied by the term "pesticide residue." Pesticide residues are chemical contaminants originating from fungicides, herbicides, insecticides, fumigants, and other agricultural chemicals used in promoting agricultural productivity by controlling the undesirable factors of production.

This presentation will discuss the beneficial properties of pesticides, their importance to agricultural production, and the risks involved in using these chemicals. Of particular emphasis will be how our industry is involved in this question of benefits derived from the use of pesticides versus the possible risks which may be encountered.

During the last 20 years there has grown a multi-million dollar industry from the need to control undesirable "pests" in man's production of food and fiber. The rapid growth of this

industry is evident from United States sales of synthetic, organic pesticides—which amounted in 1966 to nearly $600 million as compared to $262 million in 1960. Sales in 1966 were up 18 percent over 1965, a larger percentage gain than in any one year since 1955 (USDA, ASCS, October 1967). The continued growth of this industry is readily evident due to the lack of far-reaching alternative methods for the control of undesirable pests and the increased needs of agriculture to boost its productivity to feed growing populations.

It has been reported that some 10,000 species of insects in the United States are classed as public enemies, of which several hundred are particularly destructive and require some measure of control. Other pests capable of causing serious economic loss include 600 weed species, 1,500 plant diseases, and 1,500 species of nematodes (microscopic worms).

Even with modern pest control methods, insects, diseases, nematodes, and weeds still cause damage estimated at more than $10 billion annually to crops and livestock—a loss amounting to nearly one-fourth of our total yearly production.

With respect to the world food needs, several authorities have stated that the threat of inadequate food supplies in the underdeveloped countries is the world's number one problem. Maximum possible use of available control measures will be needed to attack this tremendous problem.

The dependence of today's cotton industry on agricultural chemicals is readily apparent. Increasing labor cost has made it necessary to make maximum use of herbicides for weed control. Boll weevils, bollworms, pink bollworms, thrips, cotton aphids, cotton leafworms, cutworms, fall armyworms, wireworms—one could go on and on naming insects which attack cotton. Without insecticides the economics of cotton production would not be at all encouraging. Not to mention the fungicides and defoliants which are essential to cotton production, one can readily see the dependence on today's cotton industry on these agricultural chemicals.

One could list a multitude of uses for pesticides which are extremely useful in achieving the standard of living to which we are accustomed. However, it seems only natural to find some negative factors associated with pesticide use. Pesticide residues have been the subject of books, editorials, talks, and legislation. It is the implied danger from residues that people use when talking about eliminating all uses of pesticides.

It may be helpful to explain some factors which tend to complicate the practical aspects of this problem. One of the most important, in talking about pesticide residues, is changes in the analytical methods for analyzing pesticide residues.

In the 1940's and 1950's the methods of analysis were usually of a sensitivity that would measure levels above 0.1 p.p.m. Inability to detect smaller amounts of residues led to a false sense of security. This sense of security was was shattered by the introduction of gas chromatographic analysis with ultra-

sensitive detectors. Sensitivity levels were reduced to 0.01 p.p.m. or less and low levels of residues were found in such products as milk, animal fat, and crude oils of various oilseeds.

I would like to stop for a minute and examine just how large 0.01 p.p.m. is. It is equal to one inch in approximately 1,580 miles or one inch to the distance from New Orleans to Montreal, Canada.

With this illustration one can readily see how sensitive our methods are now—and it is expected that the methods will become more sensitive as time goes on. Therefore, it is to be expected that pesticide residues may occur periodically in agricultural commodities. Now the question which comes to mind is what is the practical significance of these low levels of pesticide residues?

The foregoing discussion on newer methods of pesticide residues analysis prompted the U.S. Food and Drug Administration (FDA) to review the pesticide residue situation and the difficulties which arose out of the statutory provisions for "zero tolerances."

Among the problems which arose from this situation was a regulatory one for FDA. Many hundreds of "no residue" registrations had been issued formally by the U.S. Department of Agriculture (USDA), independently of the FDA. But then improved analytical methodology revealed that finite levels of residues could be detected in crops treated under approved conditions where "no residue" was permitted, and these crops became subject to seizure under the Federal Food, Drug, and Cosmetic Act.

This situation caused FDA to abandon the "no residue" concept and establish tolerances for "permissible residues" and "negligible residues." This change did not imply that a finite, negligible residue level is greater than "zero" but was rather a realistic admission, for regulatory purposes, that it must be tied to an analytical method of known sensitivity.

This policy change provided that all "no residue" or "zero tolerance" registrations be discontinued on December 31, 1967. The chemical companies were allowed to extend this date for one year, provided they showed that research was in progress to obtain the toxicological data necessary to establish the finite tolerances and that, in the meantime, no health hazard was involved. All pesticides will have finite tolerances for pesticide residues by the deadline date which was set for December 31, 1970, or registration will be discontinued and, therefore, pesticide usage would automatically be stopped. The pressure is now on the pesticide manufacturers to establish the toxilogical properties of the various chemicals in order to continue to market these chemicals.

Meanwhile, where do we stand with respect to pesticide residues?

The "market basket" or "total diet" studies being conducted by the FDA provide a reliable index of the residues being consumed in the U.S. diet. These studies consist of purchasing selected foods, in retail stores, in amounts which would satisfy the nutritional needs of a 17 to 19-year-old male for 2 weeks. The

foods are divided into food groups and analyzed for pesticide residue content.

During this 3-year study, almost half of the food samples contained residues and 29 percent of the samples contained more than one pesticide residue. Even though traces of many pesticide residues were found in the food samples, it was concluded that the pesticide residues in our food supply are insignificant from a health standpoint and the residues were substantially safer than the values considered acceptable by the WHO-FAO (World Health Organization-Food and Agriculture Organization) Expert Committee on Pesticides.

Mr. Duggan, FDA, in reviewing pesticide residues in foods at a Conference on Biological Effects of Pesticides in Mammalian Systems in May of 1967 concluded that "...current levels of pesticide residues in the nation's food supply are not approaching the danger level." He went on to say that of primary concern should be the indirect sources of residues such as dairy products, fish, and meat.

These indirect sources of pesticide residues are as important to our industry as direct contamination of our products. The feeding of gin trash or grazing of cotton after harvesting could cause residue build-up in fat stores of animals which could eventually contaminate the meat or milk or both. Numerous seizures of milk have been reported due to accidental contamination of feed supplies.

The widespread usage of DDT and resulting feed supply contamination led the California dairy industry to apply and receive tolerances for DDT and its metabolites in milk.

Of interest here is a study by Dr. Quinby and coworkers of the Public Health Service (Nature 270: 726. 1965) who reported values for DDT and its metabolite, DDE, in human milk obtained in the United States. Residues were present, and in greater amounts than could be predicted with data obtained in balance studies using dairy animals. In fact, the average residue level was greater than the tolerances for DDT and its metabolites issued recently by FDA for commercial whole milk. Other studies have obtained similar results. DDT is found in body fat tissue in practically everyone in this country. The present mean storage level in body fat is about 3 p.p.m. for DDT and about 8 p.p.m. expressed as DDT equivalent for metabolites. However, there has been no significant increase in the storage of DDT by the general population of the United States since it was first measured in 1950.

The National Cottonseed Products Association is aware of data which indicate that trace levels of pesticide residues may occasionally occur in cottonseed, cottonseed meal, hulls, and crude oil. However, the degree of contamination would not be unlike that of other similar commodities. Care must always be exercised to prevent undue contamination.

Since cottonseed oil is our most valuable byproduct, the Association was tremendously disturbed when on May 24, 1966, word reached us that a railroad tank car of crude soybean oil was seized by the U.S. Food and Drug Administration on the allegation that it contained

pesticide residues. Cause for contamination was not known, but pesticide manufacturers, oilseed crushers, and vegetable oil processors found themselves in agreement that a study should be conducted to verify that oil processing procedures eliminate the possibility of edible vegetable oils being contaminated with chlorinated pesticides.

The results of the study led to the conclusion, which has been accepted by both USDA and FDA, that normal commercial processing of crude vegetable oils for human consumption effectively removes any chlorinated pesticides which may be present in crude oils. It is concluded that removal of such chlorinated pesticides is achieved by volatilization during deodorization. Based on this and other studies, it appears that chlorinated hydrocarbon pesticide contaminated vegetable oils can be decontaminated during the refining process.

This joint study between the chemical industry and our industry has been an excellent example of the fine cooperation we have received. This limited study which was necessary to keep oil moving and mills crushing, both soybeans and cottonseed, cost the Association, Velsicol, and Shell an estimated total expenditure in excess of $75,000; it was costly but also absolutely necessary.

So far in this presentation, I have discussed the well-established fact that the use of pesticides is a must in today's cotton production; we must use pesticides if cotton is to be produced economically—this could also apply to other agricultural commodities. I have talked about the low level of pesticide residue contamination in our food supply, our feed products, and even our own bodies, all of which are so low as to cause no toxic or clinical symptoms. So why should we be concerned about pesticide residues?

Of primary concern would be periodic occurrence of samples of food and feeds which have significant amounts of residues present. These residues may occur for a variety of reasons: Gross misuse of the chemical; indirect application, better known as drift; and a new factor which is becoming of increasing concern to many—the gradual build-up of pesticides in the soil, with selective plant uptake of the pesticide and resulting deposition of the pesticide in the oil fraction of the seed.

It has been shown in research studies that some pesticides remain in soils relatively unaffected by either physical or biologieal factors. The Crops Research Division, ARS, USDA (Science 157: 924. 1967) has shown that when technical grade DDT was mixed thoroughly with soil, in a test plot, 39 percent of the original DDT aetivity was still present after 17 years. Under practical conditions one might find the time may be shortened; however, one could conclude that chlorinated hydrocarbons are destroyed slowly in soil and would have a natural tendency to build up after continued use. It appears that some crops grown in rotation, where previous crops were treated with certain chlorinated hydrocarbon inseeticides, may contain residues at harvest. This problem has been recognized with root, forage, and oilseed crops.

Another eoncern which we have is the ever present possibility that govern-

mental agencies may change policies which could have a disastrous effect on the registration and ultimate use of pesticides. Since several pesticides are now being critically reviewed by the FDA to develop finite tolerances for these chemicals, there is always the possibility that the recommendation could be adopted that, for the good of the consuming public, the registration should be dropped, or that the finite tolerances be set so low that it will be impossible for practical use of the chemical.

Another concern, which is presenting USDA with many problems, is the differences in permissible tolerances between those of the United States and countries to which we are exporting. The West German Government passed a law in 1966, to become effective in January 1968, which put severe limitations on the use of pesticides in Germany and ultra-low tolerances for residues. These residue tolerances are significantly lower than those established in the United States. These differences could very well limit the export of certain U.S. agricultural commodities to West Germany.

Another concern is for the unknown. What is the possibility of physiological effects of ingesting pesticides on the body even though no toxic symptoms are observed? These questions and others must be answered through additional research—the outcome of which is unknown.

As one can see, there are problems which must be solved. What logical approach should we as an industry take in the meantime? I propose that we should:

(1) Encourage appropriate use of registered pesticides to solve some of our production problems. These chemicals must be used as directed; misuse just brings on more problems.

(2) Continue to encourage a wide diverse educational program through the Association, private industry, and governmental organizations, to establish benefits, risks, and the absolute necessity for proper use of these chemicals. Dalton Gandy, of our staff, has worked hard in this activity of promoting safe use of pesticides; the progress is slow but in the right direction.

(3) Encourage research on the use of possible alternative methods for controlling these "pests." Biological control through learning enough about the insect to turn themselves against themselves offers much promise.

In summary, pesticides are essential for today's agricultural production. The future use of pesticides will be directly related to their residues. Therefore, anything that our industry can do to minimize the residue situation will be extremely helpful.

COTTON LINTERS

by
C. A. Montague, Jr.
The Buckeye Cellulose Corp.

I have been asked to discuss cotton linters. A lot has happened in the linters market from the time I accepted the invitation to talk to you.

To keep the material to be covered in line with the time allotted, I am going to change the topic a little and limit my discussion to the markets for chemical linters.

It seems to me that one of the most instructive things we can do in the area of chemical linters at this time—while we are in the midst of a periodic price gyration of linters and linter pulp—is to look back and see what has happened at similar times in the past. To do this, I want to show the historical offtake of chemical linters by markets over a number of years.

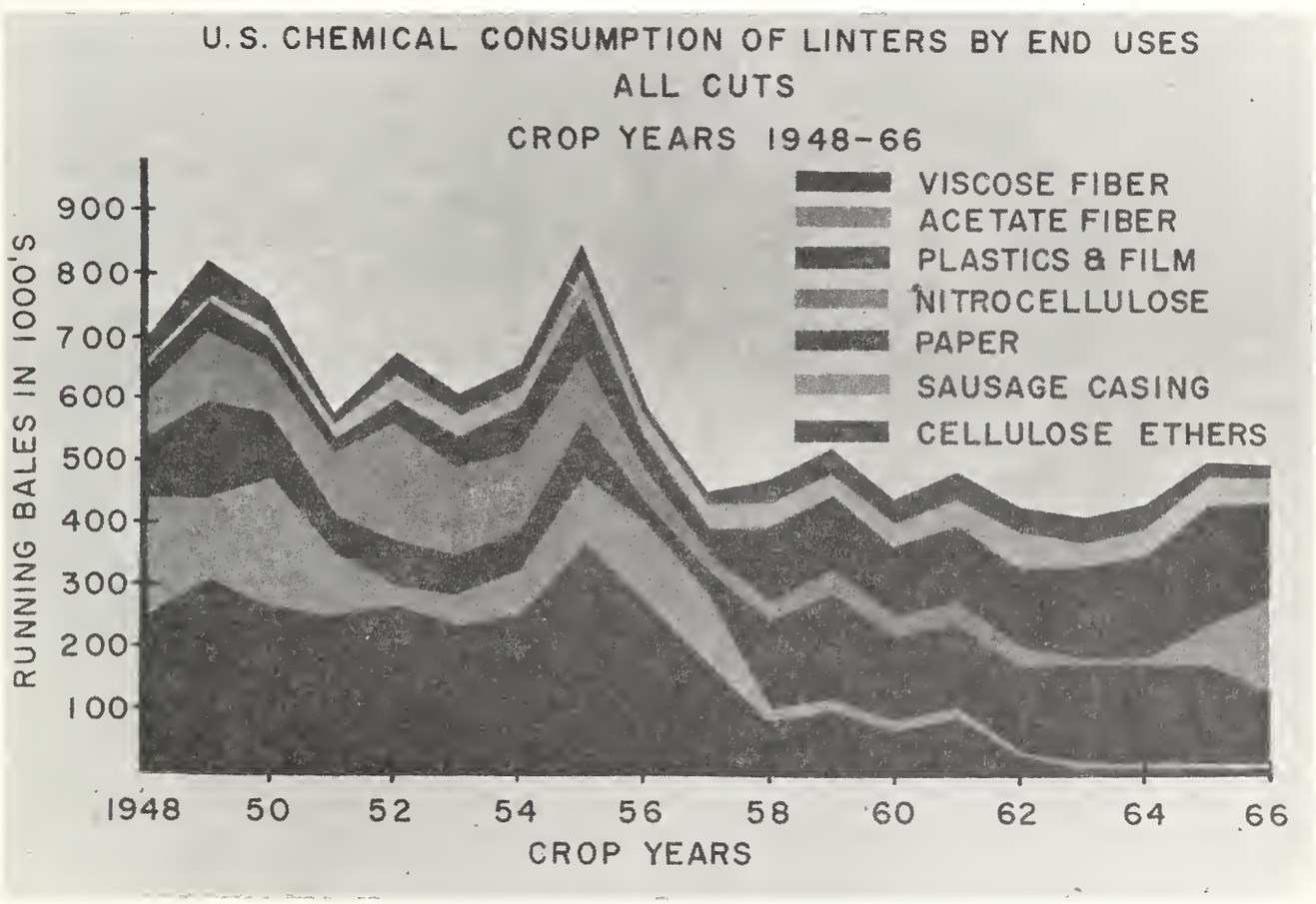

Figure 1. U.S. Chemical consumption of linters by end uses. All cuts. Crop years 1948–1966.

By looking at several products which are, or might well have been, made from cotton linter pulp that was, in turn, made from your chemical linters, we will have a general idea of the type of items into which chemical linters go.

The offtake by markets for the historical period is shown in figure 1. A study of this chart reveals several significant things. In addition to showing the simple offtake by markets, for instance, we see that we have completely lost markets which in the beginning of the historical period totaled over one-half of the total chemical offtake. These are the viscose and acetate fiber markets.

Originally we had big outlets for linters in these markets, but as the markets grew, linters, with their higher and uncertain prices, were reduced to only specialty markets within these large general markets. When our prices got high enough and the additional markets which linters could provide through their superior quality became small enough, linters were eliminated from these markets altogether. This is the sort of thing we simply cannot afford to let happen in additional market areas.

We also see that each of the remaining market areas has exhibited some price elasticity with cotton linter pulp prices. During higher price periods, people have reduced their use of cotton linter pulp and as prices have come down, they have, historically, increased their linter pulp usage.

The existence of market elasticity shows that in these market areas the consumer does have a choice as to the cellulose raw material he uses. There is an alternative to the use of cotton linter pulp! This is confirmed by statistics which show that the total end product volume has not shrunk, during periods of high prices, to the extent that cotton linter pulp consumption has. This shows simply that wood pulp has been substituted.

The degree of substitution depends on the quality of wood pulps that are available, upon the economic incentive provided by the difference between linter and wood pulp prices, and upon the quality tolerance of the respective markets.

The chart also shows that despite aggressive research, development and sales efforts, we have not been able to find enough new markets to fully make up for the loss of the big fibers markets. (New business just isn't easy to find.) Consequently, we need to do everything we can to preserve the markets we now have.

We can also see that our offtake is again concentrated in three major areas—the acetate plastics film, the nitrocellulose, and the paper areas. Because of this concentration of volume, these markets provide attractive areas for wood pulp substitutes. This hasn't been overlooked by wood pulp manufacturers and we are vulnerable to the loss of these large markets if our competitors are successful in offering entirely satisfactory pulps made from wood.

It is important to keep in mind that, in each and every market area shown, linter pulp makes up only a part of the total cellulose consumption.

Historically, linter pulp has justified its existence at high prices only by being able to supply superior quality that would justify a sizable premium market or application within a much larger total market. If the volume of business which cotton linter pulp can justify falls too low, or if price variations keep it from being profitable, users will be tempted to eliminate the use of linters on the larger wood pulp markets.

An idea of the extent to which cotton linter pulp competes directly with wood pulp in the respective market areas can be drawn from table 1.

Table 1.—Cellulose consumption by markets. Approximate annual rates, mid 1967. Air dry tons - 000's. 1/

Market	Cotton linter pulp		Wood pulp		Total
	Tons	Percent	Tons	Percent	Tons
Acetate plastics and films —	30	55	24	45	54
Ethers ————————	4	15	22	85	26
Nitrocellulose ————————	40	49	43	51	83
Casings ————————	9	64	5	36	14
Paper ————————	36	34	105	66	141
Total ————————	119	37	199	63	318

1/ Est. by The Buckeye Cellulose Corp.

This table shows cotton linter pulp's share of the total cellulose consumed in the respective market areas. The consumption figures are 000's of tons. Table 1 shows that in 1966 cotton linter pulp supplied 55 percent of the cellulose for the acetate plastics and films market; 15 percent of the ethers market; 49 percent of the nitrocellulose market—thanks to the Government business; 64 percent of the food casing market; and 34 percent of the paper market. These statistics are based on 1966 figures. When 1967's statistics are available, cotton linter pulp will be shown to have an even smaller share in each market except, perhaps, the nitrocellulose market.

Just to get an idea of "what a little frog in a big pond" cotton linter pulp has come to be, let's look at the trend of linter pulp versus wood pulp production during the period 1936 to 1966 (figure 2). It's easy to see that most anyone can find ways to get along without cotton linter pulp.

Furthermore, we know that wood pulp producers are currently taking dead aim on our position in major market areas. Several major producers have developed special purpose wood pulps for use in the acetate plastics and film areas and substantial substitution is occurring as a result. This will show up as reduced linters pulp consumption in this area during the current crop year. Also, mercerized wood pulps have been successfully introduced into the paper field at the expense of cotton linter pulps. Wood pulps are also moving into higher and higher viscosity grades of cellulose ethers such as CMC, methylcellulose, ethylcellulose and hydroxyethylcellulose.

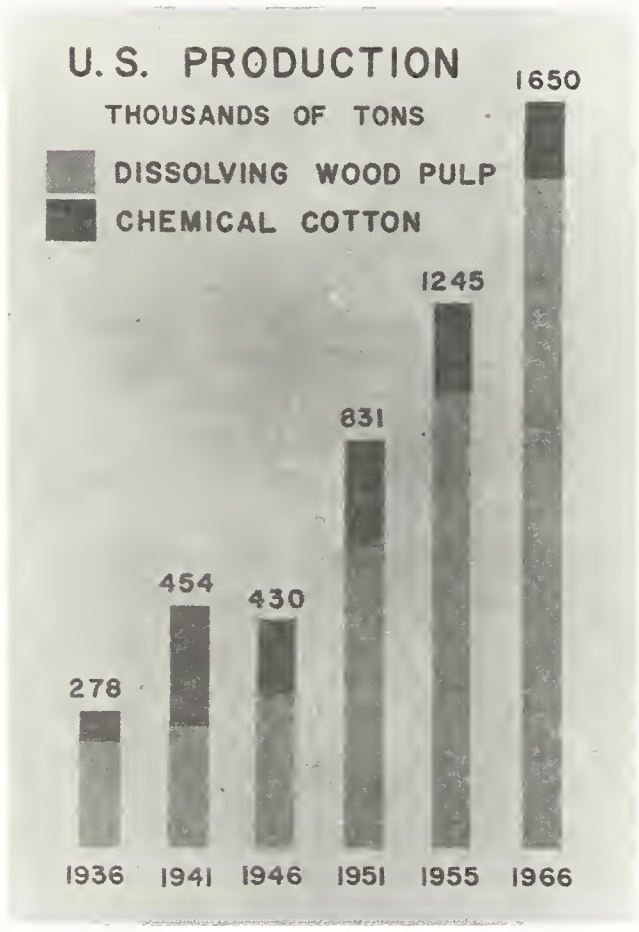

Figure 2. U.S. Production. Thousands of tons.

Just what can we do to reverse this trend? The best thing we could do would be to assure our customers of adequate supply at nominal prices, but we are unable to do this. However, we must get prices down when the linters supply will allow it, or we are dead ducks. While little can be done about this until next season, it has to remain our number one priority. While linter pulp is an excellent pulp of high purity, it simply does not justify even its current price of some $285 a ton. Needless to say, it has not justified the even higher prices that have prevailed during most of the past year—not with wood pulp selling the $200 to $215 ton range!

Second, we must restore our quality advantage or ultimately sell linters at prices competitive with wood pulp. Because selling $215 per ton linter pulp would demand 1-1/2¢ per pound raw linters, I don't believe anyone here would want us to try to do business without a substantial quality advantage.

Keep in mind that the extent of the quality advantage we can provide will largely determine the premium price at which we can sell cotton linter pulp above some $215 per ton, or, said differently, the extent of the quality advantage which we as bleachers and you as mill operators can jointly provide will largely determine the price we can pay for chemical linters above some 1-1/2 percent per pound.

Figure 3 indicated the quality race we are in. Shown are the improvements in wood pulp relative to linter pulp in recent years. To date, the best new

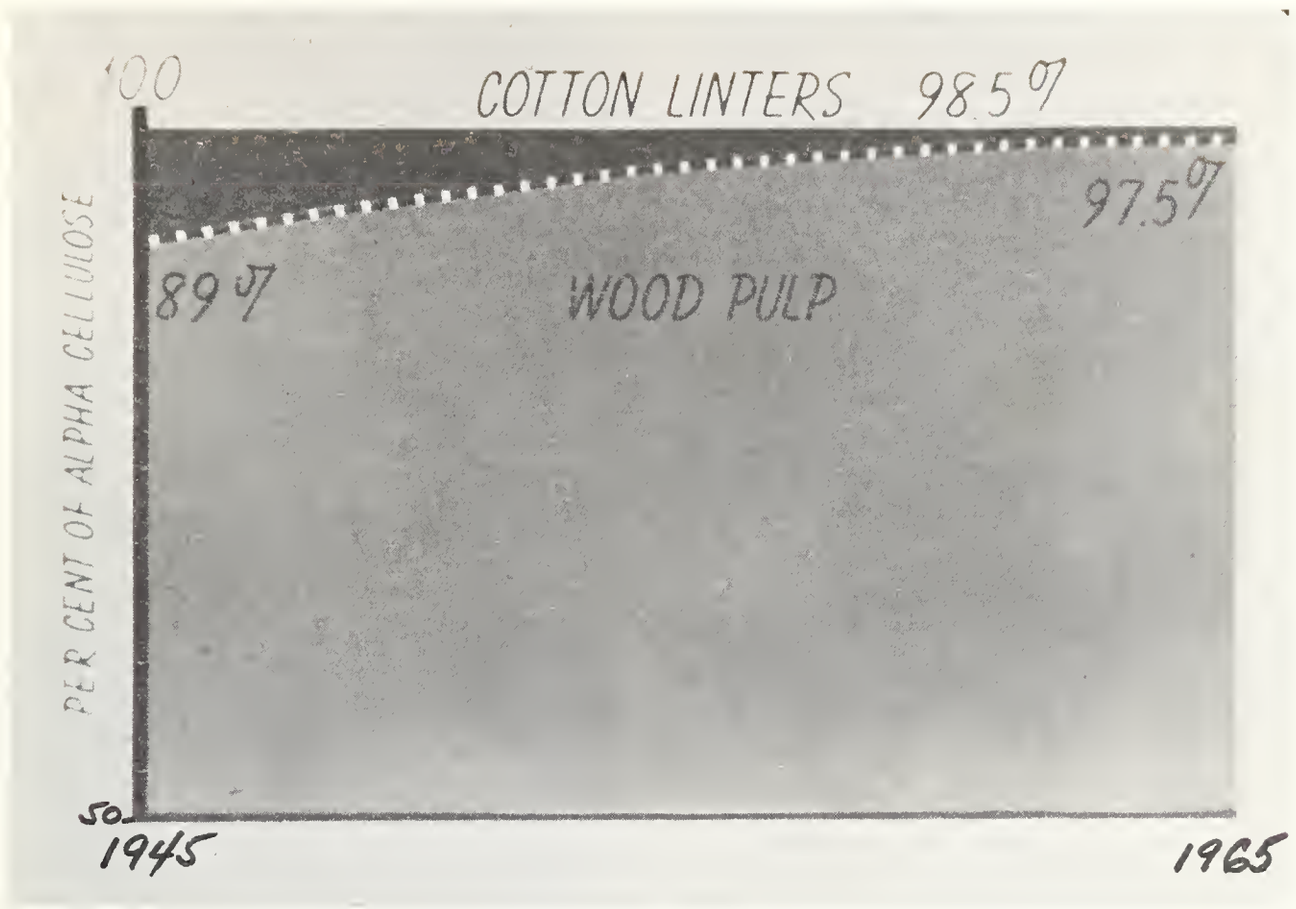

Figure 3. Improvement in wood pulp relative to linter pulp.

wood pulps have an alpha-cellulose content in the range of 98.2 percent versus linters at some 98.8 percent.

Just where do you come in? I'm sure you already know! Our earlier discussion of various end products repeatedly mentioned the importance of quality. Basically, quality in cotton linter pulp can be described as three things: cotton linter pulps which are free from particulate foreign materials, cotton linter pulps of high chemical purity that yield solutions with great clarity and freeness from color, and cotton linter pulps of high DP which indicates that the cellulose consists of molecules with long chain lengths. This latter quality allows linters to yield plastic products that are though and strong. It allows cotton linter pulp to yield ether solutions of very high viscosity. It is principally in these three quality areas that linters surpass wood cellulose. Otherwise, cellulose is cellulose pretty much regardless of the source.

The individual linter fiber consists of high purity cellulose with a minimum of resin or lignin content. As a result,

high yield linters can be chemically purified with mild processing conditions to preserve molecular length and provide high purity in the pulp.

However, when we receive linters of low yield with trash in them two problems arise. First, we are compelled to use the most strenuous of mechanical, hydraulic, and chemical purification processes available to purify the linters. Even with these processes we are only partly successful from the color and clarity point of view. We are never able to make as good a pulp from low yield linters as we can from good linters. Also, in using such strenuous purification, we may unavoidably shorten the linter molecules and reduce the potential of the pulp from a strength and viscosity standpoint.

Believe me, putting emphasis on the quality of raw linters at times like this is not simply something we do in periods of weak markets as some have suggested. This is simply a stage in the overall cycle of chemical linter price and consumption that is becoming familiar.

In periods of acceptable prices and ample supply, we have aggressively improved our pulp in order to expand volume and use of the available lint as much as possible. During such periods, consumers come to rely on linter pulps and in some product areas they temporarily lose touch with wood pulps.

When a shortage develops, customers realizing that they cannot immediately go to wood pulp engage in scare buying, taking advantage of whatever forward price protection they have and materially worsening the shortage. This forces us to do everything possible to get the necessary linters. Inevitably, we have raised prices and sacrificed quality in order to extend supplies.

At such times, the consumer works feverishly to substitute wood pulp in view of the substantial cost savings and the threat of inadequate supplies.

As demand falls, we are then forced to come up with improved cotton linter pulps to displace the improved wood pulps that have been substituted. That is the situation at the current time. We

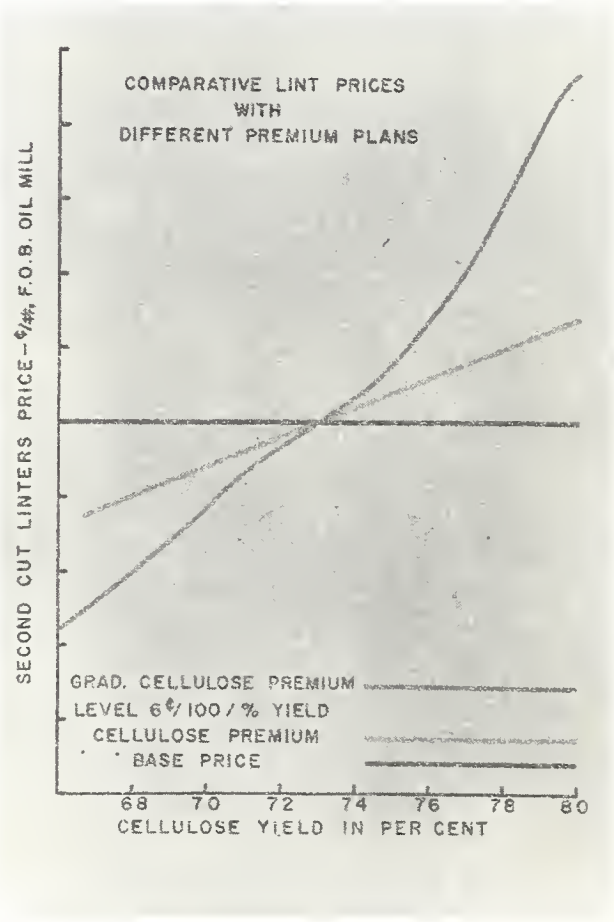

Figure 4. Comparative lint prices with different premium plans.

can do this only with your help as we can do it only with lint which is manufactured having high yield and low dirt content.

Our efforts to comc up with improved pulps are continuing at the maximum possible pace in our technical facilities. Our accelerated cellulose yield premium should provide evidence of our genuine nced for improved lint quality and our willingness to share the cost of it. The price effect of this is shown in figure 4.

As previously stated, once the dirts are entrapped in the raw lint, the pulp will never come up to its full potential. Consequently, much of our ultimate success in developing the pulps to regain our markets will depend on you and your willingness to clean seed and sell improved lint.

This does not present a very pleasing picture from the standpoint of oil mill operation where seed cleaners may already be overloaded, but we believe it to be the only acceptable course to follow. We simply can't afford to see our markets disappear. It reminds me of the story that is told of Maurice Chevalier. He was oncc asked how it felt to arrive at the age of 75. His reply was, "Not too bad considering the alternative."

Perhaps this is the point of view we all must take as we face the necessity of once again improving our products or losing our markets.

CRUSHING COSTS

by
R. B. Davis
Plains Cooperative Oil Mill

I am pleased to be on the program this morning to discuss crushing costs, which is probably the most important subject to any cottonseed oil mill at this time.

The processing cost per ton generally is not favorable at this time, due primarily to the fact that cottonseed production is down somc 40 to 50 percent due to the present cotton program. Costs sueh as labor, supplies, and other variable items should be watched closely; however, the primary costs—taxation, interest on capital investment, insurance, and property taxes—are fixed, and it is most difficult to lower them.

Nothing but an increase in cotton production in 1968 can materially lower the cost for the coming season.

As long as we use present equipment and processes, we are not going to see very much improvement in any of our costs. We are going to have to find new, better, and cheaper methods of cleaning, delinting, hulling, and separating that require less labor and less repairs.

You are well aware that this has been done in the oil extraction department. By converting from hydraulic to screw press or solvent, your labor

has been reduced to one-fourth or one-third of what it was previously. We are going to have to do the same thing in the front end of the mill.

We compete in a market where soybeans set the prices for both our oil and meal; yet our working costs on a ton of cottonseed are two to three times the working costs on a ton of soybeans.

What are we going to do about it? We must find new approaches to our problems; we will not likely find solutions with conventional methods or principles. With all the technological advances in recent years, surely there is something that can be applied to cottonseed. We are too accustomed to thinking in the same old channels. Let's broaden our outlook and our search.

I don't claim to have any solutions, but to give you an idea of what I'm talking about, let's think about processing seed in a completely different environment. You probably know that if you dip an orange into liquid nitrogen for about three seconds and then drop it on the floor, it will shatter like glass; and metals that are not ordinarily good conductors of electricity become excellent conductors at supercold temperatures.

Cottonseed may have some property like this in a new environment. Possibly, if we dip cottonseed into liquid nitrogen, the lint might break off at the point of attachment if the seed was tumbled or brushed following the immersion. The lint might then be cleaned electrostatically and packaged automatically.

The seed cost might be exploded to give a higher percentage of whole meats and separation accomplished by ultrasonic sifters.

Perhaps none of these are solutions, but they do represent different approaches.

I challenge each of you here today to give these problems some thought each day while you're shaving, driving to work, or downing that first martini in the evening. If you will do this, someone will have a progress report on a new process to give at the meeting here next year.

PANEL DISCUSSION: PROBLEMS CONFRONTING PROCESSORS OF COTTONSEED AND SOYBEAN

L. R. Watkins, Anderson, Clayton & Co., Chairman

PROCESSING OF COTTONSEED AND SOYBEAN IN A SINGLE MILL

by
J. C. Holloway
The Southern Cotton Oil Company, Inc.

First I will try to give a description of the machinery involved in the crushing of cottonseed through a solvent extraction plant. We have the 176 saw Carver linters with pneumatic attachments and flue system. The separation room has the Carver hullers and separation machinery. The press room has the French mechanical presses. In the extraction room we have the French

horizontal basket-type extractor which has 10-mesh screen fastened to the bottom to prevent the fine meal from getting through to the miscella pans. The DT (desolventizer and toaster) is a 7-ring-high, 85 inch diameter vessel. The top ring is equipped with live steam attached to the sweeps and grids that let the meal through to help in the desolventizing process. The next two rings are also equipped with three grid plates each. The remaining rings do not have grids as they are unnecessary.

The seed is cleaned, delinted, hulled, and separated. The lint goes to the baling press and the hulls go to the hull house. The meats are conveyed to the flaking rolls and from there to the mechanical presses where about 40 percent of the oil is extracted. The cake from the presses is about one-quarter of an inch thick. This cake is conveyed to the extractor and the remaining oil is removed down to one-half of 1 percent or less. The full miscella is pumped to the evaporator and then to the stripping column. The finished oil is pumped from the stripping column through an oil cooler to the storage tanks. The spent flake is conveyed to the desolventizer and toaster where it is desolventized and toasted. When the meal leaves the toaster, about 1 percent of soapstock is added. The meal is conveyed by air to the meal room where it is ground by the hammermills and then stored for blending.

The protein is held around 42 to 43 percent. This gives a better opportunity to blend back to 41 percent.

There are several changes that have to be made in the setup of the mill before soybeans can be processed. We have the French cracking rolls and the French flaking rolls. The 50 percent soybean meal machinery consists of the Sutton-Steele floaters, the Overstrom vibrating shaker, and two gravity tables. The 10-mesh screens in the extractor baskets have to be removed and the extractor speed has to be increased because of additional tonnage going through. The speed of the spent flake elevator also has to be increased to meet the requirement of the extra tonnage. The grids in the desolventizer and toaster have to be enlarged and the depth of the meal in each ring has to be increased. The spent flake dryers have to be put in working condition because these units are not used in processing cottonseed. The meal-conveying system is the same for soybeans as for cottonseed. However, the hammermill screens are changed. We use a one-fourth-inch-mesh screen on the first hammermill and a one-eighth-inch-mesh screen on the number two hammermill. Now the soybeans are ready to be crushed.

To make 50 percent protein meal the beans are dried to a moisture content of 7 to 9 percent. The beans are stored 7 to 10 days. The longer they are cured the better they will crack and separate. After the beans have cured, they are conveyed to the work tank. After the beans leave the work tank, they go over a safety shaker to remove as much foreign material as possible. From there they are conveyed to the cracking rolls where they are cracked into one-fourth and one-eighth sections. The cracked beans are conveyed to the floaters where the skins and beans are separated. The beans go to the conditioner and the skins are dropped onto

an Overstrom vibrating shaker. The fines are separated and the coarse particles of beans and skins go over the gravity tables. The skins are separated from the coarse meats and are picked up by aid and go to the skin toaster. When they leave the toaster they are run though a hammermill. After they are ground, the skins are stored in tanks to be used later for protein control. The coarse beans from the gravity tables are put into the conveyor going to the conditioner. Here moisture is added; the temperature is brought up to 160° F. The beans leave the conditioner and go to the flaking rolls. The flakes should run eight- to ten-thousandths of an inch thickness. The rolled flakes are then conveyed to the extractor. The extraction of soybean oil takes more hexane circulation than cottonseed. After the oil is extracted from the flakes, they are conveyed to the desolventizer and toaster and the hexane is flashed off. The flakes are toasted and as much moisture as possible is removed. The DT is not efficient enough to do all the drying, therefore, flake dryers have to be used to insure sufficient drying. The finished meal is conveyed by air to the meal room where it goes through the hammermills and then into storage. This meal can be shipped as 50 percent protein, or it can be blended with the skins down to 44 percent meal.

The full miscella is pumped through a miscella filter to the first stage evaporator and here 95 percent of the hexane is flashed out. The oil is pulled from the evaporator to the stripping column where the remaining hexane is removed. The oil is then pumped through the oil cooler and on to the storage tank.

This covers the processing of cottonseed and soybeans in a single plant. We have in the past crushed cottonseed and soybeans at the same time in this plant, that is, cottonseed through the mechanical presses and soybeans through the solvent plant.

OVERPROCESSING FIRST CUT LINTERS

by
S. K. Campany
Delta Oil Mill, Inc.

When the topic entitled "Overprocessing First Cut Linters" was assigned to me, I was puzzled as to just what this term meant. It occurred to me that possibly some of our more affluent mills had and were using a series of lint beating and cleaning machines designed to refine their first cut lint to the ultimate limit and that in so doing they were possibly damaging the fiber in this elaborate operation.

In checking with the USDA Testing Laboratory in Memphis, I discovered that they had not made any tests on beating or cleaning "First Cut Lint" and their testing of fibers was confined entirely to cotton.

It was suggested that I contact linter dealers and buyers in our area to determine what light they might shed on the subject. At this point I discovered

that these people were the source of the question, "Is it possible that some of our mills are overproccssing first cut lint?" Samples of first cut lint were examined, without their source or producer being revealed to me, and in several cases I found the lint in a "knotty" condition—that is, the lint appeared to have been beaten excessively which produced a "pilly" effect in the lint. This term, "pilly," I learned, is derived from the word "pill," and it was evident that small pills from 1/16- to 1/32-inch in diameter were numerous in some samples.

Wc, at Delta, have only one Fort Worth BC 4 lint beater with which to beat and clean first cut lint. Its paddles in the upper lint section are set at an angle designed to beat out any sticks, shale, pepper, and other foreign material through the 1/8-inch by 1-inch perforated screen. The paddle setting is also calculated to propel the lint through this upper lint section at a rate of speed no slower than is necessary to beat all possible foreign material through the perforated screen.

With my limited knowledge of lint-cleaning equipment, the only way I know to "overprocess" first-cut lint with our equipment is to reset the paddles to a flatter angle, thereby retarding the flow of lint through the lint chamber and almost forcing the lint to move forward by "plug" pressure from the rear.

People in the linter business and representatives of manufacturers of lint cleaners, to whom I have talked, seem to be of the same opinion; that is, first cut lint should not be subjected to any more beating than is absolutely necessary to remove whatever sticks and shale that can bc readily extracted.

Is it possible that some of us have insufficient precleaning equipment and are making an effort through excessive beating to remove foreign material that should have been extracted in the cleaner room? I know that we, at Delta, are short in precleaning equipment. For this reason our lint beater is overburdened with the task of removing foreign material that should have been removed in the process of precleaning seed ahead of the first cut linter machines.

One representative of a manufacturer of lint cleaning equipment ventured to say that some of us possibly are making a very heavy cut through our first cut linters. This would account for a higher yield of hull particles and pepper in our first cut lint going to the lint beater. He was of the opinion that excessive beating might be employed purposely to remove this extra foreign material.

In spite of all we might say about overprocessing first cut lint, however, it doesn't seem to impose a very severe price penalty in sales. The buyer seems interested in color, type of cut, and cleanliness. The overbeating gives a bad appearance, but the processor apparently is able to restore the lint to a fluffy texture in his processing machinery. It is only natural, however, that the prospective buyer, on being shown various samples within a single type category and offered at the same price, would choose a sample of fluffy texture over a sample having a knotty, overbeaten appearance. I might get an argument over the statement just made, but that

is the impression I got in talking with linter people.

In the present first-cut market, the grade categories seem to be very broad. In this situation, two different types of lint—one being somewhat visibly inferior to the other—might very well bring the same price as the other type of lint appearing superior to the other.

It has been suggested that linter buyers should be more specifically demanding in the type lint preferred for their own particular trade. If these demands or preferences were made known to the producer, it was thought that perhaps it would induce the producer to strive to utilize his existing machinery to the fullest or even install additional cleaning machinery to accomplish this purpose.

The producer's reaction to such a proposal, however, might well be as follows: At the present price offered for first cut lint, even the better grades, is it economically practical, or even worth the trouble, in view of the thin profit margin based on the spread between cost of our cottonseed raw material and our salable products?

In summary, I might repeat the statement made earlier—that both linter dealers and lint cleaner manufacturers recommend that first cut lint not be subjected to any greater degree of beating than is absolutely necessary. One linter dealer even suggested that, in his opinion, first cut lint produced from early season, clean picked cotton could be sufficiently and properly cleaned by running it through a conveyor box with slotted or perforated bottom, propelled through the conveyor box with a cut-flight conveyor.

In conclusion, I admit that I haven't given you a clear-cut answer as to why some of us are overprocessing our first cut lint. However, I have offered the opinions of people closely associated with this matter. Perhaps it might provoke a discussion, or a few arguments among the producers, equipment manufacturers, and linter dealers.

MILL-PLANT SANITATION

by
J. Howard
The Southern Cotton Oil Company, Inc.

Some of us can remember when people came to the mill to catch cockroaches for fish bait. Today the fish bait had better not be there!

When cleaner mills became a necessity, some of us thought it would be sufficient to hire an outside exterminator to take care of the rats and mice and to spray for insects when we could shut down to clean up. We soon found out that this did not get the job done.

Mr. Huge' and Doctor Holmes of the American Sanitation Institute wrote some thoughts which seem to cover the situation very well. This was published in the June 1959 issue of Food Processing, under the title "When an FDA Inspector Comes." The following is

quoted from this article:

"Major sanitation factors

"Basically the FDA believes that the major factors contributing to filth and poor sanitation in a food plant are, in rough order of importance:

"1. Human behavior that involves lack of proper personal hygiene, improper personal attire, failure to protect the product from contamination, and lack of adequate supervision.

"2. Rats, mice, and other vermin.

"3. Flies, roaches, water bugs, and other insects.

"4. Dirty and/or inaccessible food handling processing equipment and utensils.

"5. Raw materials, water, and ice supplies in an improper condition.

"6. Unsanitary toilets and washing facilities—also their accessibility.

"7. General plant structure, including surroundings, plant construction in relation to rodents and insect exclusion, general cleanliness, and cleanability.

"8. Waste disposal, dealing principally with methods of sewage disposal from the plant and other buildings in immediate surroundings, wherever this is of significance.

"9. Storing and handling—in particular—of such products within the plant that are subject to insect and rodent infestation."

Probably the best ways to discuss this problem of mill sanitation is to tell you how it has worked out for us. Our plans may not be perfect, but at least the situation is much better than it was.

(1) There is a scheduled shutdown every second week of operation for a thorough cleanup inside and outside of conveyors and machinery. Buildings and floors are blown down and cleaned. If any cleanup is needed in the yard, this is also done. A water-based pyrethrin spray is used in and on the machinery and in places that come in contact with food material. A residual spray made up of Vapona and Diazinon is used on walls and places where food never has contact. All surfaces and machinery should be dry before the mill is started up.

(2) Space spraying or fogging is done, as required, with a fire-retardant petroleum-based Pyrethrin spray. This is, of course, for flying insects and insects that are on surfaces.

(3) Rats have always caused problems around oil mills. We use what you might call a "perimeter control." This is made up of anticoagulant bait stations at 50-foot intervals around the perimeter of the property. Other anticoagulant bait stations are used within the mill area where there is no danger of the bait getting into the millstream. Traps are used in the processing areas. Barriers 3 feet high are installed on all the seed-house doors. All buildings are

rodent proofed as much as possible.

(4) Other minor tools, such as fly bait, paraffin baits for rodents, larvicides, and bird repellents, are used.

(5) Screens or fly fans are used on doors and windows that are normally open. Buildings are made as bird proof as is possible.

(6) The Diazinon and Vapona spray is used in empty seed houses where needed, at least 6 weeks before the first seeds are put in it.

(7) A separate storage area is provided for all the materials that are used. This is under the control of some responsible person at that particular mill.

(8) A responsible person, using a detailed check list, reports on the condition of every point of interest covered by the mill sanitation program. This cheek list is an individual thing for each mill.

(9) Each mill has a written set of instructions on what to do when the FDA inspector comes.

Everyone knows that a program like this is expensive and time consuming. However, if results are to be obtained, some program like this must be followed religiously and be accepted as part of the mill operation. A side benefit will be a better operating mill.

MARKETING OF COTTONSEED AND SOYBEAN PRODUCTS

by
H. W. Gilbert
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The market problems as related to cottonseed products is simple. All that is required is that buyers be found for meal, oil, hulls, first cut linters, second cut linters, and motes—who will buy when you want to sell, take delivery when you want to ship, and pay full market price or above. The solution to the problem is somewhat more complex and involves constant study of conditions, some directly and some distantly related to the actual products involved. Adequate background information is not the easiest thing to assemble and involves regular conversations with dealers, brokers, and consumers, as well as a study of all available published crop reports, stock reports, animals on feed reports, consumption reports, etc. Daily newspaper headlines also have an effect on the markets.

Now to the specifics: Nearly all cottonseed oil mill managers will agree that the local market for meal and hulls should be exploited to the fullest extent. Local mill sales are normally at retail leading to a higher margin of profit, but even if sold in wholesale quantities, there is a saving in outbound freight which can certainly be shared with the purchaser. The majority of cottonseed oil mills, however, are located in an area of feed surplus so it is necessary to compete for markets for cottonseed meal and cottonseed hulls in feed-defi-

cient areas. Here freight becomes an item of major importance, so if you are to realize the maximum return, it is imperative that you know not only the freight rate from your mill to the various consuming points, but also, the rates to the same points from other produeing areas. It is obvious that the large consumer, such as mixed feed manufacturers and large feed lot operators, are interested only in the delivered price not in the price at the mill. By selecting areas with the most advantageous freight rate from your mill, quite often it is possible to obtain a slight price improvement. Brokers and dealers are another necessary tool in the marketing of hulls and meals. It should be recognized that both dealers and brokers have more contact with consumers than any individual mill can hope to have and are in a position to find buyers at almost any time.

Not much will be said about marketing oil. We all know that there are a limited number of refiners of eottonseed oil and they purchase oil to deliver at their respective refineries at the minimum price they can obtain, again figuring freight. The exception to this, of course, is the action of Continental Grain, Bunge, and PVO, who will take a position in the market and will provide the mills one slight opportunity to hedge in the absence of an active future market.

Linters are something you sell and hope the price doesn't go down. Linters are sold subject to buyers' acceptance at the mill and it is amazing how the trash increases and the quality becomes unacceptable in a falling market.

Now, a short discussion of marketing soybean products. Basically, it can't be done profitably if the mill is a crushing operation only. Profit is to be made in mixed feed or in the further processing of the oil. The August 1966 issue of Fortune Magazine had a good write-up of the soybean industry. One of the items which caught my attention was the short discussion of hedging, etc. The obvious conclusion was that the ownership of a processing facility is superfluous.

The point I'm trying to make is that any discussion of marketing of soybean oil and soybean meal immediately becomes a discussion of hedging. Basically, there are four variations in handling marketing of oil and meal. First, the simplest consists of buying cash beans and selling oil and meal to the consumer for future delivery at a fixed price or holding the products unhedged, speculating that the spread will be maintained or improved. Second, buy cash beans and sell bean futures. This allows for delivery of beans if crushing margins become unfavorable. Third, buy cash beans and sell oil and meal futures. Fourth, buy cash beans and sell oil and meal to the consumer at so many points over or under Chicago. In this case you have the option of selling futures to protect your position of or speculating that the margin will improve.

In actual practice, marketing is a combination of all four of these approaches and requires an almost constant study of market conditions and various factors which are likely to interest speculators, because the selling price for beans or the produets is sometimes totally unrelated to the traditional

forces of supply and demand. Witnessing the situation today—we are apparently faced with a bean carryover of 160 to 175 million bushels of beans this year. The world vegetable oil price shows weakness due to the large supply of sunflower oil available in Europe and we have to contend with that dirty word "Urea" in cattle supplement which pretty well established a ceiling price on 44 percent soybean meal. In the light of all these factors, who would expect soybeans to be selling for 25 to 30 cents over the loan at river points. All of which brings me back to my first statement about marketing soybean oil and meal. It can't be done profitably from a straight crushing operation over the long haul, but judicious use of hedging can often provide an opportunity for profit.

SUMMARIZATION OF CONFERENCE

by
E. A. Gastrock
Southern Utilization Research and Development Division

The cottonseed industry is looking to the future from what is probably one of the lowest, if not the lowest, points in its recent history. However, if there is one central theme woven into most of the 22 presentations that constituted the program, it is that the industry is not discouraged. It is, I believe, convinced that the way to go is up, because:

(1) The cotton crop is here to stay.

(2) The cotton crop will be increasing.

(3) Glandless cottonseed is on the way.

(4) Glanded cottonseed can now be processed to yield a superior meal, flour, or concentrate appropriate for the nutrition of animal or man.

(5) There are excellent qualities in cottonseed protein that have hitherto been masked or concealed by processing or the presence of gossypol.

(6) The processing of other oilseeds in the same mill with the same facilities is increasing, which helps the economy of the mill by broadening the base of operations.

(7) The cottonseed industry has a long record of meeting problems and solving them either as they arise or by tenaciously seeking a solution.

(8) It must be obvious that cottonseed processing will soon undergo important changes to provide food grade protein as well as feed grade protein.

It is my humble opinion that the cottonseed industry is on the march—forward and upward.

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